Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

JUNE 1961

LIFTING RE-ENTRY VEHICLES
CONFERENCE REPORT

Bell's HIgh PERformance NAvigation System — symbolized.

He took the luck out of heads or tails

This AMF engineer had a delicate problem: to accomplish the separation of the expended stages of a multi-stage rocket. If separation occurs too soon, thrust in the nearly burned out stage may exceed the aerodynamic drag, the tail overtakes the head, and...boom. A million dollar collision and no insurance.

His solution: An acceleration switch that turns the burned out stage loose at the right split second ...a switch that makes rockets think for themselves.

His switch is compact. It is designed to work in any missile at any range with any payload. It is ingeniously simple in conception, design, and operation. A spring is attached to a free swinging hammer, the spring force acting to pull the hammer against the contact plate. At calibration the spring can be set to oppose any G from 1 to 100. When the missile is launched, the hammer is held back by the acceleration forces until the stage decays to the desired separation G. When the spring force overcomes the forces of acceleration, the hammer comes forward, strikes the contact plate, and the circuit required to make separation is closed automatically. No guesswork, no luck, no *collision.*

Single Command Concept

This simple solution to a tricky problem reflects the resourcefulness of AMF people.

AMF people are organized in a *single operational unit* offering a wide range of engineering and production capabilities. Its purpose: To accept assignments at any stage from concept through development, production, and service training... and to complete them faster...in

- *Ground Support Equipment*
- *Weapon Systems*
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- *Range Instrumentation*
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engineering and manufacturing AMF has ingenuity you can use... **AMERICAN MACHINE & FOUNDRY COMPANY**

COVER: The experimental X-15 rocket-powered aircraft, as depicted by aerospace artist Mel Hunter, glides through re-entry at the end of a ballistic arc which has taken it out of the denser atmosphere. The X-15 is just beginning such flights, the first glide-vehicle re-entries. A special report on research into advanced lifting re-entry vehicle concepts appears on page 27. (ASTRO cover plaques 11 × 12 in. are available from ARS Headquarters at $2.00 each.)

Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY INC.

Vol. 6 No. 6 June 1961

EDITORIAL

SPECIAL CONFERENCE REPORT

FEATURES

ARS NEWS

DEPARTMENTS

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Astro notes

PROJECT MERCURY COMES THROUGH

• Under a pitiless glare of publicity at Cape Canaveral, the National Aeronautics and Space Administration sent Astronaut Alan B. Shepard Jr. into space successfully 23 days after the momentous orbital flight of the Soviet cosmonaut, Yuri Gagarin. In his 15-min trip, Shepard reached 115-mi. altitude, a distance of 302 mi., and a peak velocity of 5160 mph.

• Both capsule and man performed close to perfection. From a resting rate of 105, Shepard's pulse climbed to a maximum of 115 during moments of high acceleration and returned to "baseline" when stress was removed. He took a peak reentry deceleration of 11 G. His body temperature did not change, although cabin temperature rose from 95 F at launch to 102 F during re-entry and suit temperature climbed from 75 to 78 F. The Mercury capsule's HF radio system did not function, probably because it received inadequate warmup during the brief test. The only other malfunction was an instrument panel light which failed to indicate jettison of the retromotor pack. Shepard remedied this with a manual override switch.

• Of crucial interest to NASA Space Task Group officials was Shepard's manual control of the capsule. His flight plan called for complex attitude-control maneuvering in yaw, pitch, and roll, including stabilization of the capsule during retrofiring by means of the difficult manual-proportional (mechanical) system and capsule stabilization during re-entry by means of the more sensitive manual-electric system.

• The Astronaut's success in the control excercise confirms the suitability of the Project Mercury simulator training program, and indicates that it will not be necessary to qualify astronauts on expensive suborbital flights before committing them to orbit.

• Shepard's crowded capsule-maneuver schedule contrasted sharply with the reported activities of Yuri Gagarin during his 108-min flight. Gagarin ate, drank, floated in his space cabin, wrote notes, read instruments, and transmitted by voice and key to the ground, but at no time, apparently, did he undertake active control of his spacecraft, according to Soviet reports.

• Gagarin served as a backup to the autopilot in event of a malfunction, such as the control difficulty which occurred on two Soviet spacecraft flights last year. In the Mercury suborbital flight, on the other hand, there was never any question of returning to earth, and the dynamic stability of the capsule in the critical speed ranges was intended to assure safe re-entry even in the event of malalignment.

• Brief though it was, Alan Shepard's ride will earn him records for altitude and payload in a ballistic flight. These are two of five new space records established by the Federation Aeronautique Internationale, official keeper of the world's flight records. The other three apply to orbital flight—weight, altitude, and duration—and will surely go to Yuri Gagarin, provided the Russian claim is adequately documented. This will require the Russians to record the number of motors and thrust of the launching rocket.

• Shepard's glittering success was preceded by two unmanned capsule flights in April in which the boosters failed. First of these was an Atlas launch (MA-3) intended to send the capsule on a single circuit around the earth and recover it 300 mi. east of Bermuda after a 110-min flight. Its passenger was a "crewman simulator" to absorb oxygen and emit heat, moisture, and carbon dioxide to put a load on the life-support system. Shortly after launch, the beefed-up Atlas failed to roll or pitch as programmed. It was destroyed by the range-safety officer at 15,000 ft. The short built-in delay allowed the capsule's emergency-escape system to operate. The capsule itself was plucked undamaged from the water 300 yd off the beach. It was determined that an astronaut would have survived this mishap.

• The other booster malfunction occurred on the last of the Little Joe shots at Wallops Island, Va., to test the capsule escape system under maximum aerodynamic loads. One of the six solid-propellant rockets was slow to fire, resulting in an unplanned pitchover by the booster. The abort maneuver took place at 12,000-ft instead of at 40,000 ft. There was no reduction in the planned peak speed of 1100 mph. As a result, the capsule was subjected to G forces three times greater than anticipated. Despite this, it was picked up 8 mi. off shore apparently unscratched.

• Project Mercury's schedule provides for two more Redstone flights, one this month and the other later in the summer, probably with Astronauts John Glenn and Virgil Grissom. A third Redstone booster is available. There is still a possibility that the U.S. can orbit an astronaut this year, but at least two or three fully successful unmanned orbital flights will be necessary to qualify the Mercury-Atlas system. NASA's Space Task Group remains optimistic that the Atlas booster will come through because of its success in the MA-2 flight in February.

• Out of the manned Mercury-Redstone ballistic flight came more than the expected good performance of the capsule and astronaut and the mildly hysterical response of a poorly informed public. Despite the pioneering of the Vostok flight, the Russian achievement lacked genuine worldwide participation. And just this factor will grow increasingly important in the evolution of space programs. Worldwide meteorology and communications, for example, depend on a community of approval and action. The response of British Interplanetary Society Secretary Kenneth J. Carter after the flight may be taken as indicative of the value of an open space program: "It was a great privilege to be allowed to participate in Shepard's flight," he told a reporter. "I saw pretty well up there in the capsule with him. The Americans had the right way of doing it. Unlike the Russians, they allowed us all to take part in this fantastic adventure."

• Further acceleration of the follow-on Apollo program appears inevitable. The House Science and Astronautics Committee authorized an extra \$47.6 million for Apollo in fiscal year 1962—on top of the \$29.5 million asked in the Eisenhower budget and approved without change by the Kennedy Administration. The Apollo increase was part of an \$88.7 million total authorization increase voted by the House Space Committee for NASA's

fiscal 1962 space budget, which the Administration pegged at $1.2 billion. The extra Apollo funds should assure the one-year speedup (to 1965) in the target date for the first Saturn-boosted three-man orbital laboratory.

• Even more vigorous increases are in the works. President Kennedy is expected to order an all-out U.S. drive to place a man on the moon in this decade, possibly as early as 1967. Under the existing schedule, this is the target year for an Apollo circumlunar flight using the C-2 Saturn booster. Associate NASA Administrator Robert Seamans estimated that an all-out effort to put an American on the moon will cost as much as $40 billion (compared with Mercury's projected total cost of about $400 million) and that it will at least double NASA's eventual annual outlays to a level of $5 billion in a few years.

MAN IN SPACE

• Commenting on the flight of the Vostok, the USSR Press Dept. makes these statements in an official release: "The time has come for the practical creation of extraterrestrial scientific stations-observatories for space travel to the moon Mars, Venus, and other planets of the solar system . . . We are to expect shortly the use of outer-space apparatus for the solution of several practical problems. Weather service and ice reconnaissance, relaying of television and radio broadcasts and communications, various extensive scientific observations outside the earth's atmosphere are only the first steps in this direction. They will be followed by manned flights to the moon and other planets of the solar system."

• At a meeting on mathematical biology sponsored by the New York Academy of Sciences and the Univ. of Chicago, Sidney Roston of the Univ. of Louisville presented a mathematical model of the cardiovascular system which indicates that blood pressure in the arm, for instance, might be completely independent of pressure in the aorta or elsewhere in the body. He suggests broad measurements of blood pressure, including the heart's electrical activity.

• Will strong magnetic fields physiologically affect astronauts? Attempts to demonstrate a significant biological effect of a sustained magnetic field (8000-14,000 gauss) on White Swiss mice have been unsuccessful in tests performed by Eiselein et al., as reported in the May issue of *Aerospace Medicine*.

• Spacelabs Inc. will design a system for continuously measuring and telemetering blood pressure of crew members in hypersonic vehicles for the AF Flight Test Center, Edwards AFB. This company has built and demonstrated surgically implanted systems for taking and telemetering an electrocardiogram.

• Chance Vought's Astronautics Div. has developed a flexible water-loaded blanket called Thermosorb. It has been used for insulation of space-vehicle compartments, and sounds interesting for suit design.

• The new name for the School of Aviation Medicine at Brooks AFB, Tex., is the School of Aerospace Medicine.

• One of the test flights of the Mercury capsule pointed up a problem in space-vehicle construction—how to keep it clean. Dirt floated like flak in the capsule during the weightless period.

SPACE SCIENCE

• What figure can be assigned the astronomical unit? Russian and U.S. radar experts disagree. Izvestia gives the newest figure derived from Russian studies at 149,457,000 km (92,812,797 mi.) plus or minus 5000 km (3205 mi.). Jet Propulsion Laboratory scientists, just having completed a two-month radar study of Venus, at the Goldstone Tracking Station in the Mojave Desert, derive a figure of 149,599,000 km (92,956,000 mi.) plus or minus 1000 km (621 mi.). The JPL people have confidence in this figure, which agrees well with a corrected Lincoln Labs figure.

• The Russians also report a period of rotation for Venus of 9 to 11 earth days. JPL scientists say this period is far shorter than what they estimate on first look.

• The Soviet Union has ordered a drastic shakeup in the management of scientific research. The move strips the Academy of Sciences of its former authority over the direction of Soviet science and assigns it to a new Committee for Coordination of Scientific Research Work. The group is headed by Lt. Gen. Mikhail V. Khrumichev, former boss of Russian aircraft production and deputy chairman of the State Planning Committee.

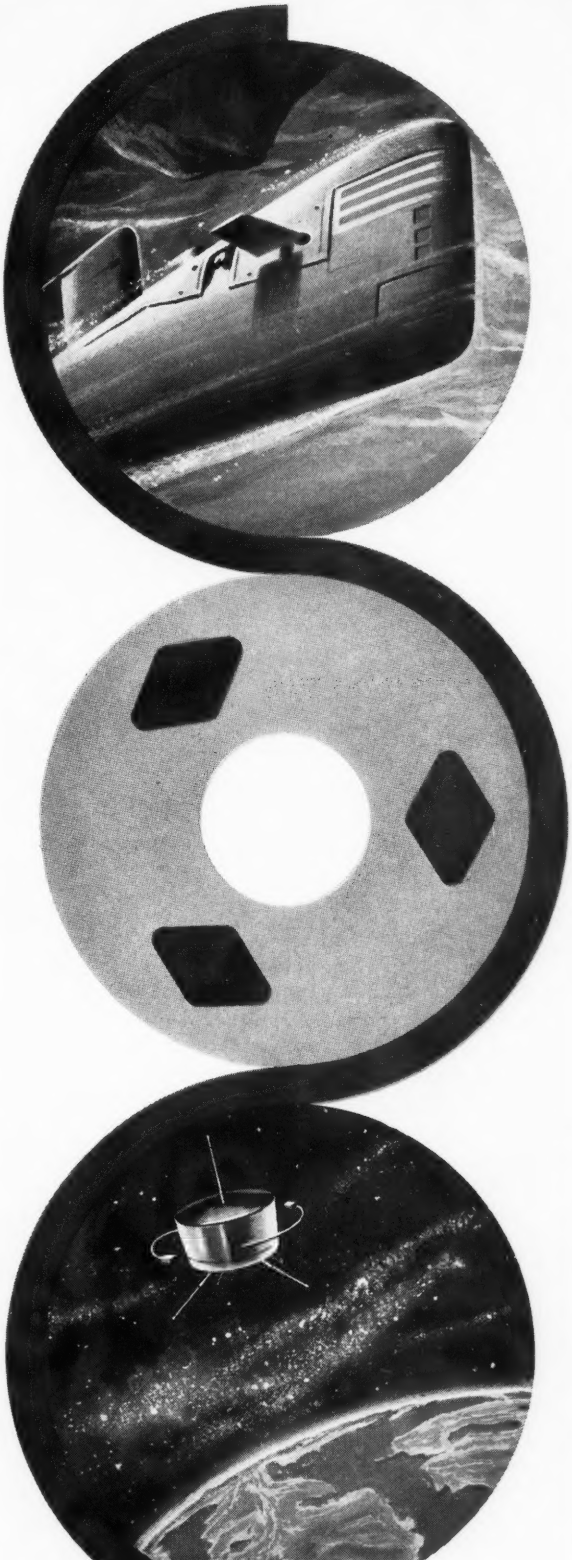
• U.S. scientists attending the annual spring meeting in Washington were sharply critical of NASA's policy of relying on fewer but larger space vehicles to accommodate scientific payloads in the future. John A. Simpson of the Univ. of Chicago and Bruno Rossi of MIT declared that there should be more opportunities for scientific launchings, not fewer, and suggested the U.S. may lose its scientific leadership in space by overemphasis on booster development and manned space vehicles. "There are so many new discoveries to be made that it would be a shame not to exploit them," Dr. Simpson said.

• The moon was the target of some ingenious scientific speculation at the American Geophysical Union meeting in Washington. Thomas Gold of Cornell Univ. suggested that the moon might contain large amounts of water and ice, depending upon the presence of hydrated silicates at the time of its formation. S. Fred Singer of the Univ. of Maryland presented a theory on the so-called "electronosphere" just above the lunar surface. Dr. Singer believes that in direct sunlight the lunar surface acquires a positive charge of about 20 volts from the ionizing component of solar radiation. Dust particles kicked up by occasional meteorite strikes thus cannot settle back to the surface because of electrical repulsion, though they quickly lose charge when they fall into shadow. He estimates the density of these particles to be about 1 per cc at an altitude of a few yards. Radar probing of the moon suggests some such "smooth" reflecting surface.

• The National Radio Astronomy Observatory has begun construction of its 300-ft-dish partially-steerable radio telescope and expects it to be ready for tests in the spring of 1962. This radio telescope will weight about 500 tons, cost $400,000 to fabricate and erect, and have a pointing precision of 2 min of arc. It will move in elevation only —from 30 deg above the southern horizon through zenith to a like distance above the northern horizon. The earth's rotation will carry its beam through a selected radio source, the correct elevation angle being given its instruments.

• With a Juno II booster, NASA successfully launched the 94-lb Explorer XI (S-15) gamma-ray telescope to map the sky in the ultra-energetic range of 100-mev photons. The experiment, first of its kind in orbit, should provide valuable data on the density of interstellar matter, origin of cosmic rays in specific points like the Crab

(CONTINUED ON PAGE 10)



SOUNDCRAFT INSTRUMENTATION TAPE IN SPACE AND UNDERSEA WITH TIROS II* AND THE SEA DRAGON

The Tape Selected For The Video System In Tiros II! Orbiting with the Tiros Weather Satellite II, developed by RCA for the National Aeronautics and Space Administration, Soundcraft Tape is used exclusively in both narrow and wide angle video tape systems. Only 3/8 of an inch wide, this tape records longitudinally rather than across the width and is the result of over five years of research.

On The Nuclear Submarine, Sea Dragon, the first undersea magnetic video tape recorders also developed by RCA, used Soundcraft instrumentation tapes to record and store data on under-ice characteristics of icebergs and ice flows. As man probes deeper and deeper into the unknown, science continues to call on the world's most modern tape plant for reliable magnetic tapes.

Discover how Soundcraft's consistent record of accomplishment can be extended and applied to fulfill your recording needs. Write for complete literature.

*Soundcraft Instrumentation Tape is, of course, used in Tiros I, and in other vital space projects as well.

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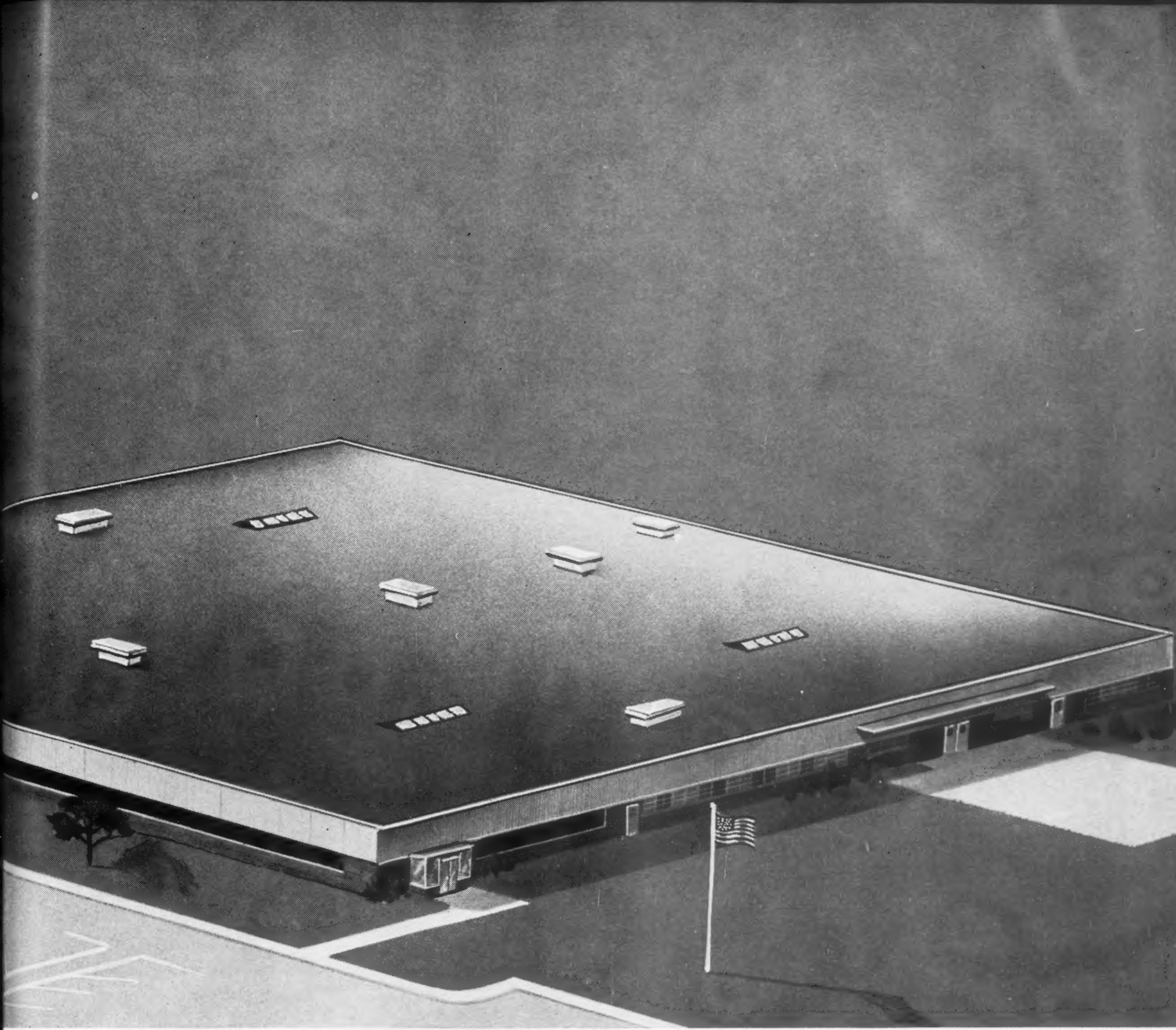
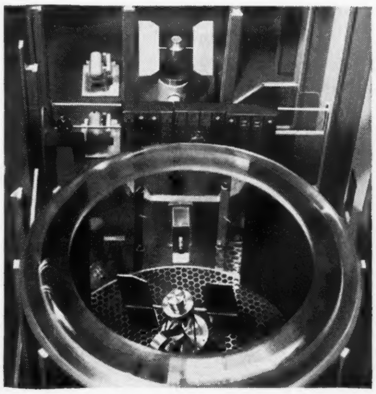
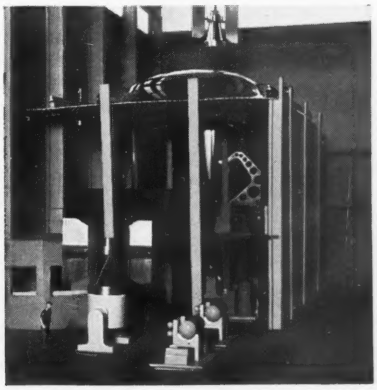
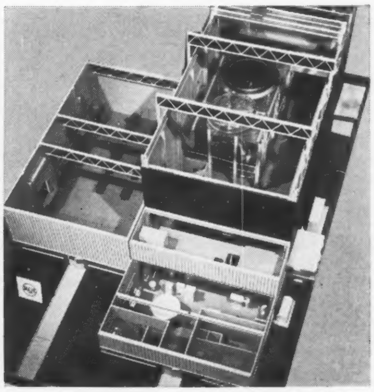




New advanced Vacuum-Thermal facility shown in model has pumping system that can reduce pressure to 5×10^{-6} mm Hg within 24 hours with a 3500-pound payload in the enclosure.



New Vibration System will include 28,000-pound exciter driven by an amplifier capable of delivering 140 KW over a frequency range of 25 to 10,000 cps.



All existing environmental equipment will be housed here and a new high-bay assembly area provides facilities for assembly of an increased number of space systems.

Nebula, and the question of whether there is continuous creation of matter in the universe. The gamma-ray telescope was designed and built by George W. Clark and William L. Kraushaar of MIT's Laboratory for Nuclear Science.

• NASA announced agreement with British scientists on the second United Kingdom satellite to be launched on the Scout vehicle. It will measure galactic radio emissions too long to penetrate the ionosphere, vertical distribution of ozone, and micrometeorite size and density.

• The Explorer X magnetometer had the great good fortune of encountering a solar storm during its 60-hr battery life following launching March 25. Preliminary study of its telemetry record seems to indicate the existence of a relatively steady proton flux of 10 particles per cc traveling outward at 300 km per second—the so-called "solar wind." Associated with this wind is an interplanetary magnetic field which was measured both in a strong, stable condition and in the highly disturbed condition as a result of solar activity. Although too early to be definite, there were signs that Explorer X might have collected advance notice that a solar flare was on the way which would involve proton bombardment of the earth. If this is correct, Explorer X may provide a strong lead in developing a solar-storm forecasting technique—vitally important to astronauts on extended space flights.

SPACE TECHNOLOGY

• Fins will be added to Saturn boosters for certain missions, and tested on early C-1 Saturn shots.

• General Electric Co. announced the formation of Communication Satellites Inc. as the base of a joint-venture common carrier for operation of a commercial communications satellite system. The new company simultaneously applied for authorization from the FCC to establish point-to-point microwave relay circuits for telephone and record traffic. Under GE's plan, the new firm will be owned jointly by interested U.S. aerospace and communication firms as well as by interested foreign governments and carriers.

• GE put up $1 million to finance initial operations of the new company, and said it would be willing to add $25 to $50 million more if it receives a go-ahead from the government. The GE proposal is a direct challenge to American Telephone & Telegraph Co., which is building its own experimental satellites and an earth terminal at Rumford, Me.

• AT&T is seeking government boosters to orbit its payloads in response to offers made by former NASA Administrator T. Keith Glennan during the Eisenhower Administration. It has become increasingly apparent, however, that the Kennedy Administration does not want to commit itself to any commercial arrangement without a careful scrutiny of the entire situation.

• The Administration's coolness to AT&T's demands for a quick go-ahead suggests to some Washington observers that the Bell System's hold on international telephone traffic may be broken. This does not mean that AT&T will not dominate any joint venture approved by the government (contrary to GE's proposal that each participant be limited to 10% ownership); but it does appear that other companies may gain a place in international telephone service.

• English and French telecommunication agencies have already agreed to participate with NASA in its Relay and Rebound studies of active and passive satellite communication systems.

• The Systems Div. of Bendix Corp. received a $17,260,000 Army contract to develop the Project Advent (earth-period military communications satellite system) satellite repeater, special ground equipment, checkout equipment, and systems engineering. Bendix-Radio will be responsible for ground terminal equipment, and will install and operate it at two sites, one near Fort Dix, N.J., and the other near Camp Roberts, just north of Monterey, Calif.

• Armour Research Foundation will act as the hub of DOD's tri-service program to analyze and control radio interference in this country and abroad. It just received a $2 million contract for technical support in this program. ARF activities under the contract will eventually shift to a permanent facility at the U.S. Naval Engineering Experiment Station, Annapolis, Md.

• The Air Force awarded Philco Corp. a $35.8 million contract for continued development of command and control systems for AF space and satellite programs, such as Discoverer and Midas. Philco will be an associate prime contractor and report directly to the AF on its advanced work.

• The X-15 continued to set new speed and altitude records. As *Astronautics* went to press, NASA test pilot Joe Walker was preparing for a speed attempt of 3400 mph (Mach 5.1)—a target some 326 mph faster than the X-15's mark of 3074 mph with AF Maj. Robert White at the controls. Its "current" altitude record, set by Walker, is 169,600 ft.

• NASA announced the successful firing of a seven-stage solid-propellant rocket at Wallops Island to investigate hypervelocity re-entry problems. Designated Trailblazer I, the vehicle measured 56 ft long and weighed 7700 lb. Its first three stages carried it to an altitude of about 175 mi., and then the next three stages fired down. Mounted on the head of the sixth-stage spherical rocket motor was a special gun-type explosive accelerator which propelled an artificial steel "meteor" into the atmosphere at a peak speed of 25,000 mph.

• Design note: The Institute of Mechanics of the USSR Academy of Sciences has requested representation at the International Hypersonics Conference to be held Aug. 16–18 at MIT.

• Orbital rendezvous can be accomplished by the astronaut using simple, light guidance equipment which requires little training to operate, according to Martin-Baltimore. Its Advanced Programs Group, headed by E. E. Clark, has been studying rendezvous with simulator equipment. Findings have been included in the Apollo feasibility study which Martin will be submitting soon to NASA.

PROPULSION

• The House Space Committee added $23.5 million in development and construction authorizations to the Rover nuclear rocket program and called upon NASA to select engine and vehicle contractors at the earliest possible date. It criticized NASA and the AEC for dwelling over the issuance of proposal requests on the Nerva engine for approximately two months before sending them to industry.

• Rocketdyne is developing a liquid-hydrogen-cooled nozzle for the Kiwi-B test series of the Rover program. The nozzle is constructed of tubes of Inconel X designed to

handle heat loads ten times greater than conventional chemical rockets. Rocketdyne reports more than 35,000 sec of successful operation of an axial-flow turbopump to force liquid hydrogen through the Kiwi-B reactor. Kiwi-B tests are scheduled to commence late this year in Nevada.

• Radio Corporation of America is experimenting with VHF and UHF radio-pumping techniques to accelerate a mercury plasma. Ions and electrons are generated by successive electrical discharges in a pool of mercury. RF power is then applied to the plasma, which attains velocities as high as 40,000 mph within 2 in. of the experimental apparatus. The technique does not require heavy magnets to accelerate the plasma.

• In recent Congressional testimony, Atlantic Research Corp. advanced the idea of semisolid ("gel-solid") propellant to gain simplicity and handling ease with large boosters. ARC's concept calls for segmented construction with the propellant slurry pumped into trays within the case. Exhaust stacks would conduct the combustion gases from each tray to nozzles. ARC said it has fired more than 100 small gel-solid motors with complete success.

• Proposals were due June 1 on a contract to supply six 105-in.-diam tanks for the Saturn first-stage booster. NASA's Marshall Center outlined requirements to bidders at Huntsville early in May. The Saturn booster consists of one 150-in. tank surrounded by eight 70-in. tanks. The big tank and four of the smaller tanks carry lox; the remaining four tanks carry kerosene. Production of the big tanks would begin in April 1962.

• NASA reports considerable improvement in propellant utilization and operating efficiency of ion engines under development at the Lewis Research Center, but adds that the problem of beam neutralization remains unanswered. To determine whether theoretical solutions are correct, it will fly a laboratory-model ion engine in a Scout vehicle late in 1962. Successful recombination of the ions with electrons is vital if ion-propulsion systems are to achieve highest efficiencies.

• A list of ion-propulsion contracts and an important statement from JPL concerning their use appears on page 34 of this issue.

• Aerojet-General's Aetron Div. received $4.8 million from NASA's Marshall SFC to complete the design of the new Saturn static-test facility and to procure equipment for it.

• Moving ahead under its AF contract, Aerojet-General static-fired a 25-ton two-segment solid-propellant rocket motor 65 in. in diam at its Sacramento facilities. The motor developed 160,000-lb thrust "for a duration commensurate with the requirements of full-scale segmented units." The firing took place under the technical direction of the Directorate of Rocket Propulsion (Edwards AFB) of the AF Systems Command. Aerojet is now fabricating much larger segmented motors.

• Rohm and Haas received a $1 million ARGMA contract for continued research on solid propellants.

• Marquardt received $4 million from the AF for Project Pluto nuclear ramjet research.

• Hercules Powder came out with a proposal for producing 50-ft-high, 300-ton solid boosters by manufacturing the propellant in 100,000-lb segments, erecting the segments at the launch site, and then casing the segments with a glass fiber winding (Spiralloy). The technique has been demonstrated in small motors, according to Hercules.

WEAPONS

• Bizarre space weapons continue to attract USAF research attention. Latest scheme is an electrostatic projector for whipping tiny bits of metal and other particles up to a "hypervelocity." Such a projector might be used against missiles and satellites above the atmosphere. Armour Research Foundation has received two contracts totaling $147,000 to investigate development and use of hypervelocity weapon systems.

• The Titan ICBM program passed a major milestone at Vandenberg last month with the missile's successful launching from a 146-ft-deep underground silo. The bird used in the test was a Titan I, but information gained from its launching will be used in the development of the storable-fuel Titan II, which is designed for direct silo launch to minimize exposure on the surface.

• The Army will buy the French wire-guided Entac anti-tank missile as armament for infantry units Decision to buy the missile came after trials of the German Cobra, the British Vigilant, and the French SS-10. The wire-guided Entac weighs 37 lb in its launcher-container, 27 lb in flight. The Army will phase out the SS-10, which it is presently using, as Entacs become available.

• AF awarded General Electric a $10-million contract to instrument 47 target re-entry vehicles for tests of the Army's Nike-Zeus anti-ICBM at Kwajalein beginning in Jan. 1962. The GE devices will be installed in Atlas and Titan nose cones to provide miss-distance indication for the Army's target practice. No decoys are planned in initial tests to be run against 29 Atlas and Titan missiles; but the Army has purchased 18 Atlas missiles for realistic Zeus trials in a full-scale decoy environment.

• Douglas Aircraft announced that it has established two separate technical organizations—one for space and one for missiles—within its engineering department. According to R. L. Johnson, chief company engineer for missile and space systems, "the changes are a recognition that missile technologies have been slowly diverging along rather clear lines from space technologies during the past few years."

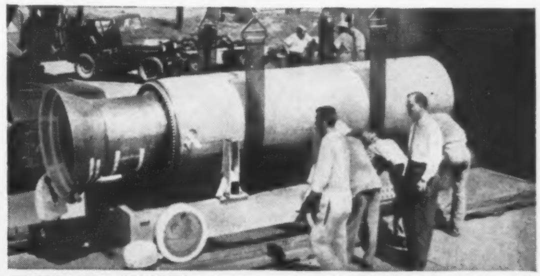
STRUCTURES AND MATERIALS

• Why go slow on the Apollo project plans for a circumlunar mission? Implicit in a discussion of motion and heating of lifting vehicles during atmospheric entry by A. J. Eggers and T. J. Wong of NASA-Ames (see report, page 27) appeared part of the answer. Spacecraft for entering earth's atmosphere at superorbital speeds cannot be designed adequately as yet without vastly more research to elucidate the full significance of such flight phenomena as nonequlibrium ionization and radiation. For instance, the nature of radiant heat transfer at extremely high-speed re-entries, these experts believe, may dictate less blunt vehicle designs than have been proposed. One design they suggest employs folding wings.

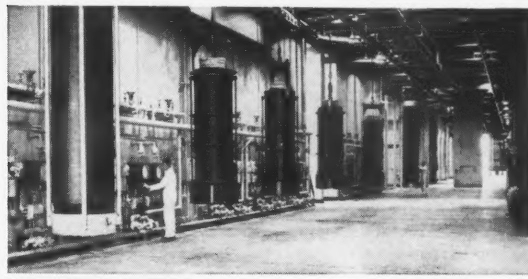
• Along these lines, samples of boron "pyralloy," an alloy of pyrolytic graphite, show the highest bending strength of any present material at temperatures above −1800 C, according to High Temperature Materials Inc. of Boston, with GE and Raytheon one of the largest producers of pyrolytic graphite. HTM is developing a family of graphite alloys, in part with the support of the Navy's Bureau of Weapons. ♦♦

research through production

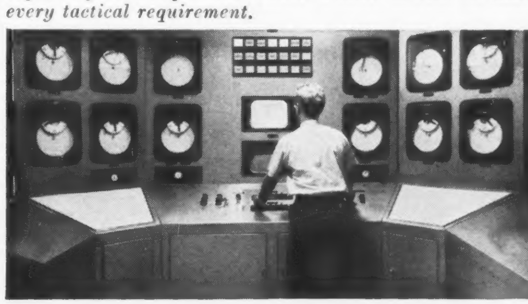
NIKE HERCULES
Air Defense Missile
Prime Contractor: Western Electric
Missile: Douglas Aircraft



REDSTONE *The most powerful single solid rocket booster ever fired in the free world—450,000 lbs. thrust—was developed for the Army's Nike Zeus program at Thiokol's Redstone Division. The motor is a product of research from propellant formation to scale-up and development of largest thrust rocket motor to-date.*



LONGHORN *Production techniques of the most advanced nature are featured at Longhorn, to assure the military a steady flow of rocket motors of unvarying dependability. Through combined divisional efforts, Thiokol is producing reliable power-plants for the key air defense and anti-missile missiles, the Army's Nikes ... Hercules, now operational and guarding major population centers ... developmental Zeus, whose repeatedly successful R&D launchings underscore Thiokol capability to design and deliver rocket motors to meet every tactical requirement.*



ided by other Thiokol Divisions. Utah, for large engine production — RMD, for sophisticated iquid systems -- Elkton, for diversified special motors.

Experiences gained through their development . . . basic laboratory research into high energy uels and materials, new processing and evaluating nethods, automatic production and quality control echniques, the most advanced and fluid research and nanufacturing facilities... all have added immeasur-ably to the progress of Rocketry, U.S.A. All can be rought to bear in the most challenging future proj-ects of the space age.

THIOKOL

THIOKOL CHEMICAL CORPORATION, Bristol, Pennsylvania
Rocket Operations Center: Ogden, Utah

For the record

The month's news in review

April 1—DOD assigns AF responsibility for operating all reconnaissance satellites; Army will process the data.

April 3—U.S., Britain, and France announce cooperative program for transatlantic testing of U.S. communication satellites.

April 8—AF launches Discoverer XXIII into orbit, but re-entry capsule stays in orbit.

April 12—Russian, Yuri Gagarin, makes first orbital space flight in the 5-ton spaceship Vostok.

—AF fires Blue Scout II nearly 1200 mi. into space to map radiation.

April 19—Navy launches Polaris more than 1100 mi. from submerged submarine Robert E. Lee.

—Atlantic Research explains potential of "gel-solid" fuel for large rockets.

April 21—AF Maj. Robert White flies X-15 to new controlled-flight speed record of 3140 mi.

—Pentagon places curb on information about missile firings.

April 25—Project Mercury test shot is aborted at 16,000-ft altitude when vehicle veers off course. However, capsule performs satisfactorily before and during its brief flight.

April 27—Explorer XI, carrying gamma-ray telescope, is sent into orbit.

Mail bag

Psychology for Man in Space

Gentlemen:

I read with some concern Dr. Charles E. Goshen's recent article on psychological research and man in space in the March issue of *Astronautics*. It strikes me that Dr. Goshen is barking up the wrong tree. He has the common problem of seeing the world in tight categories. His distinction between physiology and psychology will not hold up, for these labels demark only broad bands on a continuum: They are not separate entities.

Psychologists are concerned with man in space from many different aspects. The goal of this concern is to insure man's effective performance of whatever space mission assigned. Since any number of factors can influence performance effectiveness—physical, biological, emotional, cognitive, social etc.—the psychologist must be prepared to deal with these variables, either singly or in combination in as rigorous a way as possible.

Most of us who are concerned with the mission rather than our own professional prerogatives are becoming distraught over what seem to be some attempts to raise bogeys about man's existence in space. To cite one example, it has been suggested that social isolation and sexual deprivation will put our astronauts at the edge of (pardon the expression) lunacy. This is so patently nonsensical when one looks at the performance of early explorers of the West, or Polar explorers or, better yet, the neighborhood Roman Catholic priest, that it is no wonder that responsible technical people are leery of supporting investigations based on such assumptions. Moreover, what makes these people such as Goshen think that space vehicles will not be radio-equipped. Social isolation may never enter into space operations if technical improvements in communication keep pace with other developments.

The point is, let us get on with the job and not make it more difficult by imagining problems that may never exist.

J. S. Kidd
Associate Supervisor
Laboratory of Aviation Psychology
Ohio State Univ.

Dr. Goshen's Reply

It is difficult to comment on Mr. Kidd's criticism, since his points of disagreement do not appear to be related to the content of my article "Man in Space and Psychological Research," but to certain assumptions he has arrived at from other sources. The article said nothing, for example, about sexual deprivation, although this might be worth a comment. Isolation often leads to boredom, and boredom in humans tends to lead to fantasy, which in turn is likely in certain kinds of people to lead to sexual problems. These, however, would not be primary problems but incidental ones.

The criticism of the distinction drawn in the article between the subjects of physiology and psychology is valid only if applied to an investigator, but not if applied to the subject material of the two sciences. They are two distinct fields of study, in which an investigator might be skilled in either or both.

An analogy might be used to illustrate the difference between the physiology and the psychology of the human brain. The former could be compared to the technology of printing and publishing books, while the latter would be comparable to the study of the content of the texts of the books. A total understanding of books would include both, of course, but they are totally different subjects, requiring very different methods of study, and the latter is necessarily a qualitative one.

Understanding the differences inherent in physiology and psychology does not require that we commit ourselves to one and ignore the other, as Mr. Kidd seems to imply. My plea was for greater accuracy in reporting which is which, so as to avoid creating an illusion that the psychology of the astronaut is being studied when it really is not.

From Previous Correspondence with the Editor:

The mechanistic style of thinking tends to equate humans with machines in the sense that both are assumed to respond (output) in a manner which is a function of their input. The truth, however, is that humans respond in a manner which is a function of the prediction each human makes of what the results are going to be. If the individual predicts uncomfortable or otherwise unsatisfactory results from a given response, he will then alter his response in the hope of gaining a more desirable result. For example, there are many profound errors being made by the military service in respect to the casualty producing effects of new weapons because they fail to take account of the fact that defensive strategy will inevitably be altered in order to reduce casualties to an acceptable minimum. Instead, it is assumed that the same defensive strategy employed for other types of weapons effects will be employed in the future. Another case in point is the tendency for the stock market to behave in a manner contrary to expert predictions. In this case, the predictions, once made, result in many people seeking to take advantage of the consequences of the predictions, and the corresponding actions therefore alter the predicted results.

I had hoped that my remarks might serve to stimulate some healthy thinking in the field of human behavior.

Charles E. Goshen

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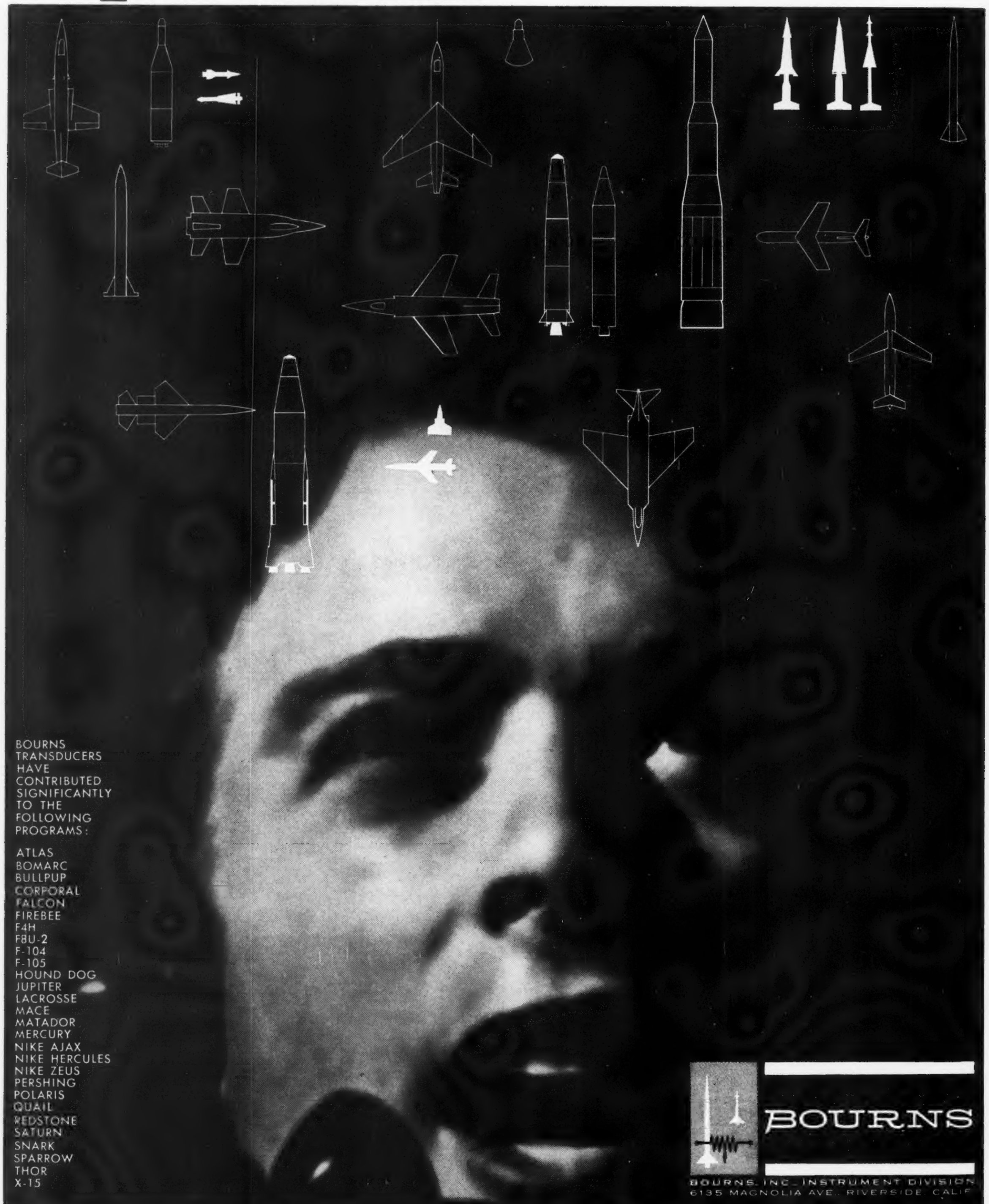

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Birth Control of Meetings

ON APRIL 20, a meeting was held at Bedford, Mass., which could have significant portent for ARS and for the astronautics field.

It was a gathering of the Guided Missiles Council of the Aerospace Industries Association. The Council invited four societies—ARS, IAS, AAS, and SAE—to discuss with it the proliferation of technical meetings.

While this subject was covered in last month's editorial, the meeting helped answer some very pertinent questions:

Just how much are these four societies to blame for the number of meetings? Mr. Frank W. Fink of Ryan Aeronautical Co. had his staff analyze 141 meetings held in 1960 which were of potential interest to aviation and space companies, and found that ARS, IAS, AAS, and SAE held only 26 of them. The rest were organized by other societies, industry, the military, the universities, and small groups.

Who is to blame for meetings that never should have taken place in the beginning? This is the question that has everybody doing mea culpas. Too often, it was agreed, meetings are irresponsibly born—the creation of organizations (societies, the military, branches of government, the AIA itself, universities, companies, etc.) seeking to stake a claim in a certain discipline, or of people seeking self-glorification, or of sections of the country wanting attention.

ARS, although not without sin in the past in this respect, pointed with deserved pride to its procedure, developed over the last two years, which gives the responsibility for initiating specialist meetings to the Technical Committees *only*.

Who is to blame for poor quality in a meeting? Both industry and the societies share the blame. ARS Director Martin Summerfield reported that the editorial records of *ARS Journal* show that 50% of the papers received by ARS should not have been permitted to be sent out in the first place because their content was so poor as to justify rejection. The societies, ARS included, could bear down on the screening of papers; too many of poor quality have appeared at technical sessions.

Industry got a well-deserved blast from its own spokesmen in Bedford for simultaneously complaining about poor meetings and then attending them anyway.

On the other hand, we all agree how important good meetings are. Consider, for instance, a study conducted by Dr. Edward Wenk Jr., senior science specialist of the Library of Congress (and an ARS member), for the Senate Committee on Government Operations was released recently. It says there are more than 160,000 tasks being performed in the physical sciences in as many as 9000 research installations involving $12 billion in outlays; and,

"If good scientific work is done but information does not flow promptly about it and from it, much of its value may be dissipated."

Professional societies exist mainly for the purpose of seeing that technical information *does* flow promptly. ARS, for its part, will continue to do its best to see that the flow emanates from quality sources, is well filtered, capably controlled and directed into the most effective channels.

James J. Harford, Executive Secretary,
AMERICAN ROCKET SOCIETY

Launch operations challenge

Our evolving space program demands a new philosophy of launch-vehicle operations to replace the present cumbersome, costly, and technically inadequate one we arrived at by circumstance

By William A. Fleming

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, D.C.

William A. Fleming, NASA's Assistant Administrator for Programs, joined the staff of the NACA Lewis Research Center, Cleveland, Ohio, upon graduation from Purdue Univ. in 1943 with a Bachelor degree in aeronautical engineering. During most of his 16 yr at Lewis, he was actively engaged in turbojet, ramjet, and turboprop research. Upon becoming assistant chief of the Propulsion Research Div. in 1956, he assumed responsibility for direction of the propulsion research in all full-scale altitude facilities at the laboratory. During his last two years at Lewis, he directed much of the transition from air-breathing engine to chemical rocket research in the major altitude and supersonic tunnel facilities. He was transferred to NASA Headquarters early in 1960, and was recently appointed to his present position.

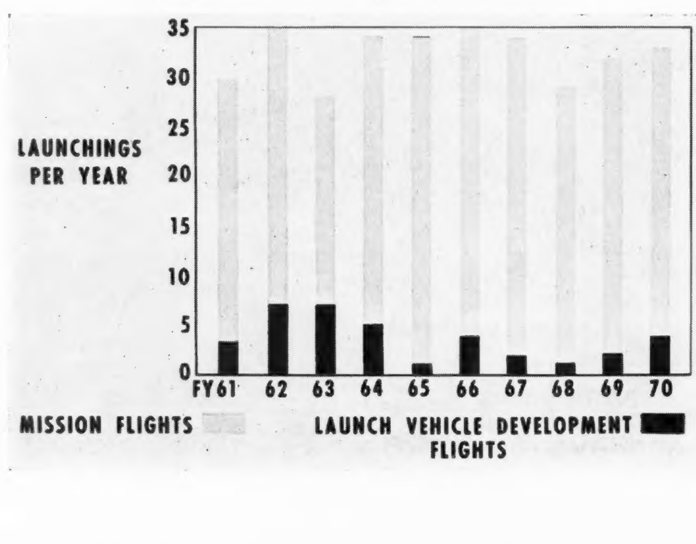
No doubt every engineer engaged in launch-vehicle development has dreamed at one time or another of that day when vehicles will flow from the contractor's plant directly to the launch pad, there to be fueled, counted down in a brief and effective manner, and launched on missions with a high degree of reliability—*no* prelaunch static tests, no fervent rebuilding of the rocket by enormous field crews in the shadow of the launch pad, and no seemingly endless day-after-day manual checking and rechecking of each of its many critical components.

A number of our leading launch-vehicle people at NASA believe we can move much faster toward this ideal than we are at the moment; believe we can cut down the tremendous cost of launching our vehicles and simultaneously improve their reliability; believe it is urgent that we accomplish this improvement in operating efficiency as rapidly as possible. But the question is, "How shall we proceed?"

To put this subject into perspective, we need first to review the objectives of NASA's space-exploration program.

As you know, NASA passed its second birthday last October 1. The President and Congress created the agency because they both

Number of Launchings per Year
Operational and Flight-Test Vehicles



felt very strongly that the scope of the U.S. space program should be extended far beyond strictly military applications.

We organized on the run, carrying out an operational space-flight program simultaneously. Progress in getting our program into motion has not been without a strong hand from industry; we have seen to it that 75% of our current year's billion-dollar budget goes to private industry, and this percentage will increase in years to come.

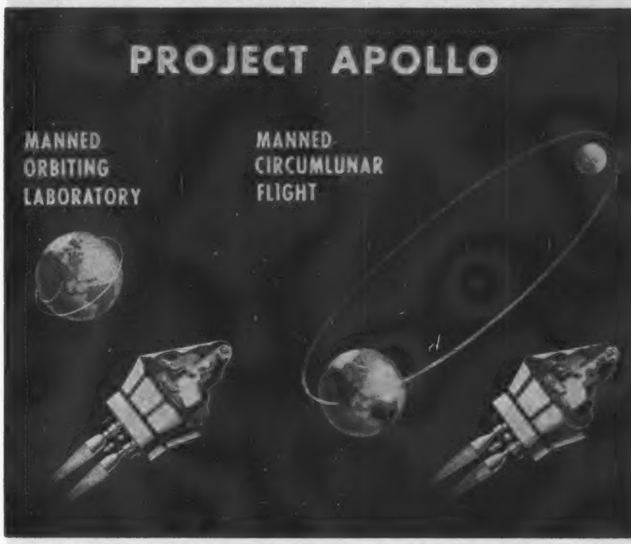
We now have a long-range plan for space exploration spanning the period 1960–70. A fundamental part of our program deals with scientific investigations using earth satellites. During the next several years, the Explorer and gamma-ray telescope satellites and probes will be replaced with mammoth orbiting geophysical, solar, and astronomical observatories, each carrying a multitude of experiments. These jumbo satellites will tell us much in addition to what we have already learned about the nature of the earth, its environment and solar influences.

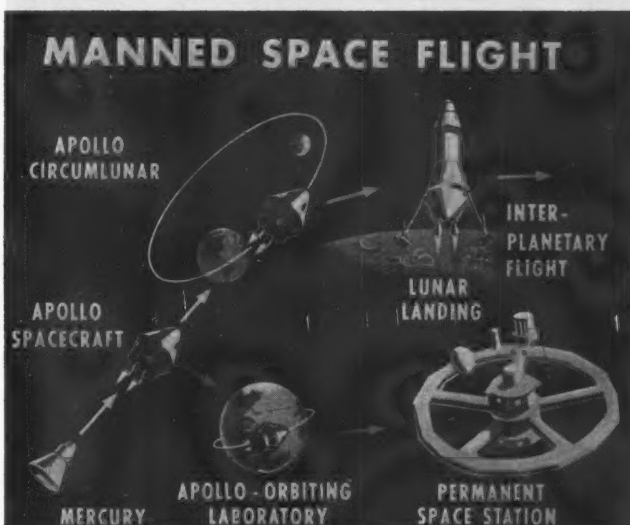
A large portion of our effort during the next decade will be devoted to unmanned exploration of the moon and nearby planets—projects Ranger, Surveyor, Prospector, Mariner, and Voyager.

Basic Questions Will Be Answered

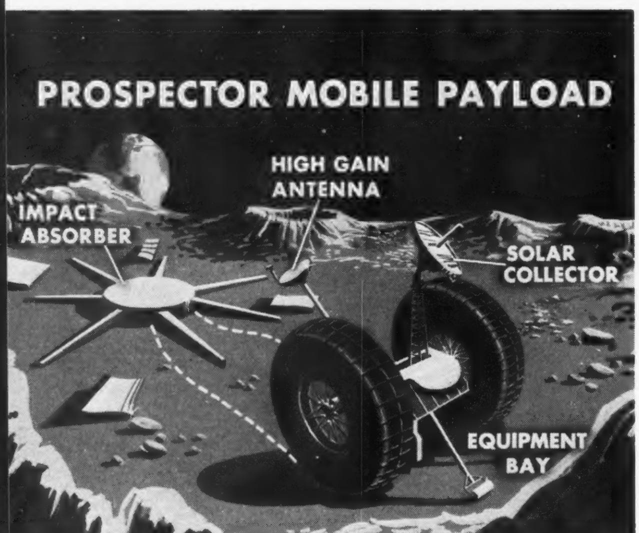
Manned space flight—projects Mercury and Apollo—will also play a major role in our program during the next 10 yr. Together these lunar, planetary, and manned space flights will lay the groundwork for manned expeditions to the moon and nearby planets in the decades that follow, and tell us much about their composition, atmospheric environment, and the nature of life forms that may exist. But further and even more important, the very nature of these neighboring bodies may hold answers to some of the most important questions in science: How was the solar system created? How did it develop and change? What is the origin of life?

Another very important effort in our space-flight





About 40% of the NASA budget presently goes to the launch-vehicle program. As our whole space program expands to include major manned operations, deep-space explorations, and regular scientific surveys—such as depicted here and on the following pages—the burden of this commitment to launch operations will become an inhibition, technically and economically. We must adopt an entirely new philosophy of how to design, manufacture, test, and launch our vehicles, says the author, if we would have the technical facility and economy of operations that will sustain our space plans.



program is the utilization of space for immediately practical purposes. This area of our program has been highlighted by the Echo I passive communications satellite and the Tiros I and Tiros II experimental meteorological satellites. Echo and Tiros moved us quickly toward operational systems. In the communications field, we are continuing our work in the area of passive communications satellites with Project Rebound, and have expanded our efforts to include active communications satellites with Project Relay. At the same time, we have pushed the development of a second-generation meteorological satellite, Project Nimbus.

We estimate that this program will require an average of 30 major vehicle launches per year—a total of about 300 launches—during the next decade, as indicated in the bar chart on page 20. It should be evident that a very large portion of the NASA budget will be devoted to the development of launch vehicles. Currently, about 40% of our budget is devoted to this area.

To improve the effectiveness as well as the reliability and economic aspects of our launch-vehicle program, we are currently making a transition toward standardization of our launch vehicles. We aim to standardize on a relatively few vehicles that will cover the entire payload spectrum from 150 to 45,000 lb in a low earth orbit—Scout, Thor Agena-B, Atlas Agena-B, Centaur, and Saturn. Our launch-vehicle development efforts will be devoted to shaping these five vehicles into a reliable stable of workhorses that will support the needs of our space-flight program for the next several years.

Three of the vehicles on which we are standardizing have as a first stage either the Atlas or the Thor, both of which are well-tried operational vehicles in the ballistic-missile program. However, when Agena-B or Centaur upper stages are mated with these vehicles, we find that a total of several weeks' preparation time is required at the launch site in preparation of the complete vehicle for launch.

To illustrate what actually takes place at the launch site in preparing these vehicles and their upper stages for flight, let me describe briefly my own impressions upon my first visit to Cape Canaveral about a year ago. I was taken first to a large hangar, just one of several similar hangars, in the vehicle-preparation area at the Cape. Here were arranged rows of delicate and expensive electronic equipment neatly stacked in racks. Adjacent to them was a launch vehicle in partial disassembly, with many of its delicate vitals removed.

The engineer in charge proudly described how they delved into each vehicle upon arrival—exposing its delicate parts—removing and testing them—completing some of the final touches of manufacturing that the press of time had prevented completing at the contractor's plant. All this, he explained, is

Studies such as Apollo and Nova introduce thinking about precise launchings without extensive countdowns. The sketch at the right was used in a Republic Aviation proposal for Apollo. Although not selected for a study contract, Republic will devote its new astronautics Research and Development Center to such advanced systems and the challenges they introduce.

necessary to locate and correct deficiencies still remaining in the vehicle when it left the plant.

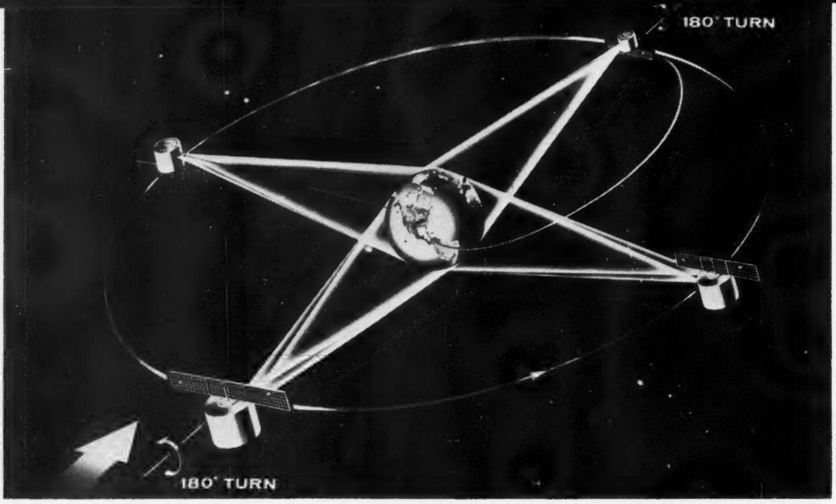
Indeed, here on the beach at Cape Canaveral, exposed to the salt- and sand-laden air, was a miniature assembly plant complete with checkout equipment. Nearly every step of vehicle assembly could be accomplished here, and the checkout equipment at the plant was duplicated in its entirety. Here were repeated many of the steps previously completed in the carefully controlled and protective environment of the contractor's plant.

Next came an inspection of a launch pad. Here I observed one of our giant vehicles nearing launch readiness. It had spent several weeks on the pad, with a large crew of mechanics and technicians swarming busily around it, manually checking each of the many items that *must* function properly for a successful launch.

All of this activity I witnessed in the hangar and on the launch pad consumed a total of *six weeks* for each launch vehicle. This is the length of time that both the first and second stages of this particular vehicle must spend at the Cape in testing, checking, and partial disassembly prior to launch. Here too were a total of several hundred men busily engaged for a period of six weeks to prepare the launch vehicle for flight. This amount of time and effort typifies what it takes at the moment to launch all of our major vehicles.

In striking contrast, we are actively planning space missions that, of necessity, do not admit such operations. Future trips of large spacecraft to the moon or planets will require rendezvous in orbit for the purpose of refueling the propulsion stage. The rendezvous will be followed by launch from orbit to the moon or a planet. When our first crew of astronauts lands on the moon, they must launch themselves on their return flight to earth without the aid of a massive launch crew and miniature fabrication plant.

How can our present launch-preparation techniques be rationalized in the face of the requirements of such missions? Why cannot the techniques we will soon be forced to develop for launches from an earth (CONTINUED ON PAGE 48)



Saturn payload to a 24-hr orbit

What are important considerations for guidance and control in placing a communications satellite in a 24-hr, earth-period orbit with the Saturn vehicle?

By Walter Haeussermann

NASA MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALA.

Walter Haeussermann is director of the MSFC Guidance and Control Div., responsible for guidance, control, navigation, instrumentation, and network systems for Saturn and future NASA space vehicles developed at Marshall. His background includes a doctorate in physics and mathematics from the Institute of Technology at Darmstadt, three years of work in guidance and control at Peenemeunde, and research again at Darmstadt for the German Army and Navy. In 1948, Dr. Haeussermann joined Wernher von Braun's team and engaged in the development of guidance and contol systems for ballistic missiles, becoming in 1954 director of ABMA's Guidance and Control Laboratory, and transferring to NASA in the same position in July 1960.

BY THE 1963-64 period, the Saturn vehicle, being developed by the Marshall SFC for NASA, will provide an efficient and reliable system for projecting multiton payloads into high orbits around the earth and into deep-space trajectories. The three-stage Saturn C-1, for example, will be capable of putting 4000 lb into a 24-hr, earth-period (stationary) orbit. Our subject is the nature of such a mission in terms of guidance and control. We will look first at Saturn guidance and characteristics of the 24-hr satellite.

An all-inertial system has been selected to provide guidance during the ascent of the Saturn vehicle, since a radio or radio-inertial system would require an extensive net of ground stations to cover the ascent trajectory in various azimuth directions, according to the different mission requirements. The sensing components of the early Saturn vehicles will be similar to the inertial components of the Jupiter missile. They have been selected for their excellent accuracy and reliability record. The accelerations of the vehicle will be measured by means of pendulous integrating gyroscopes on a gyro-stabilized platform, and will determine corrective signals necessary to compensate for unpredictable flight deviations, such as those due to wind and thrust pertubations or resulting from loss of thrust, should one or two of the eight first-stage booster engines fail to function during flight. The corrective signals provide for flight-path corrections and for proper termination of thrust of the third stage. Vehicle control about all three axes is exercised by swiveling of the four outer engines of the first stage and of all engines of the second

Design for an Earth-Period Communications Satellite

and third stages during their operating times.

New let us look briefly at some facts about the 24-hr satellite.[1,2] A 24-hr satellite is one with orbital period equal to sidereal period. If this satellite is placed in an equatorial circular orbit, and if it rotates in the same direction as the earth, it appears to be fixed over its subpoint on earth. Such a satellite is attractive for communication purposes because fixed antennas can be used on earth. The fixed antennas permit simple ground equipment.

Satellite Positioning

To achieve the sidereal period, the satellite has to be positioned 22,236 mi. above its subpoint; it can then be observed from points on earth within 71 deg, because satisfactory reception can only be obtained at elevation angles larger than 10 deg above the horizon. A system of at least three equally displaced satellites must be used for communication purposes to reach any station on earth except those close to the poles.

The illustration on page 24 exhibits a possible configuration of a communication satellite to which one receiving and one transmitting antenna are mounted rigidly. Each one is designed to possess an illumination cone of somewhat over 18 deg to cover the earth completely and to permit some angular freedom for the satellite, which is attitude-controlled with respect to the earth.

It is only theoretically possible to place the satellite exactly over its desirable subpoint; for practical reasons, tolerances have to be permitted. Thus, it may be assumed that it is acceptable to put the satellite into an observation cone of 2-deg cone angle centrically about the ideal line of sight. Furthermore, it will be assumed that, despite all its advantages, an equatorial launching site will not be available and that the ascending flight path into the circular equatorial 24-hr orbit will begin from the Atlantic Missile Range, a nonequatorial launch point. A dog-legging maneuver becomes necessary because of the change of flight planes. It means a lower satellite weight than what can be obtained by an ascent originating from the earth's equator.

A study for different injection schemes has been carried out by the Aeroballistics Div. of MSFC, and reported by R. F. Hoelker and R. Silber.[3] According to the most economical method proposed, the

space vehicle and the third stage of Saturn will be brought into a low-altitude circular parking orbit, which is inclined against the equatorial plane as a result of a due-east azimuth at launch, as shown in the figure on page 25. In either the first or the second node of the parking orbit with the equatorial plane, an impulse is applied by the engines of the third stage to inject the vehicle into the Hohmann transfer ellipse, which still lies in the inclined plane and terminates with an injection and dog-legging maneuver. This maneuver is again given by the third-stage engines, and puts the satellite into an equatorial, high-altitude waiting ellipse. The eccentricity of this ellipse is a function of the desired longitudinal position of the communication satellite in the 24-hr orbit.

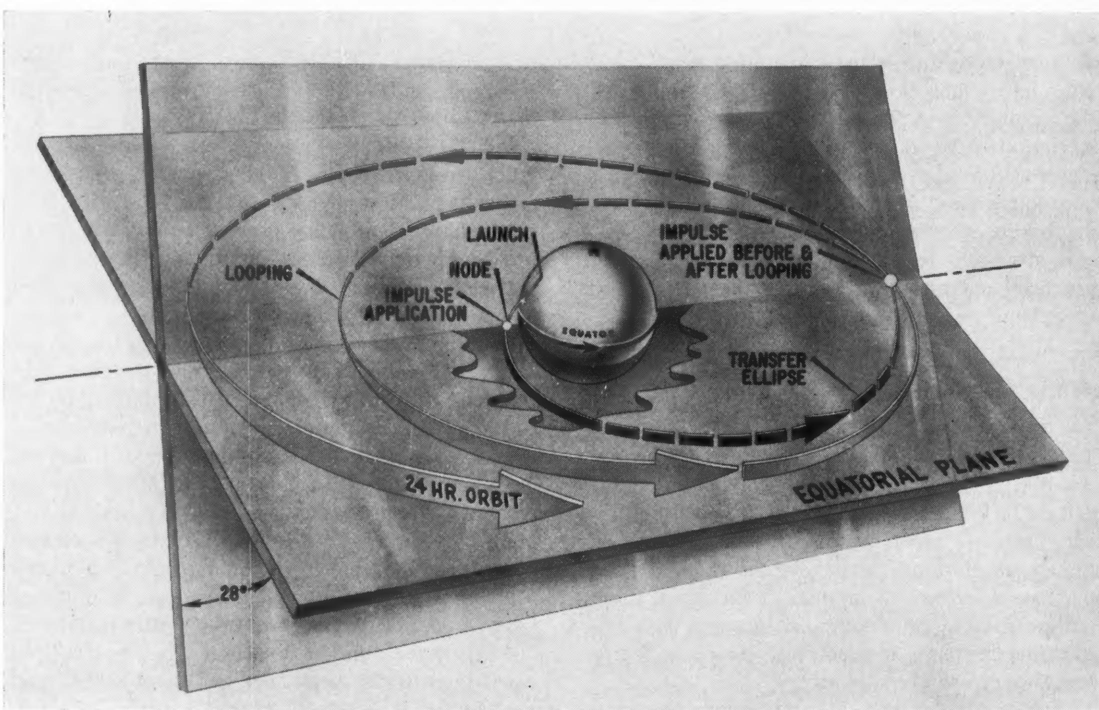
Final Corrections

The ellipses for different longitudes can be selected so close to the 24-hr orbit that they demand only small velocity increases for circularization. These velocity changes, estimated to be about 100 meters per second, are of the same magnitude as those needed to correct finally for unpredictable guidance inaccuracies. To obtain such a small velocity increment for the last injection, it becomes necessary to permit 6 to 7 revolutions, equivalent to about the same number of days, for waiting.

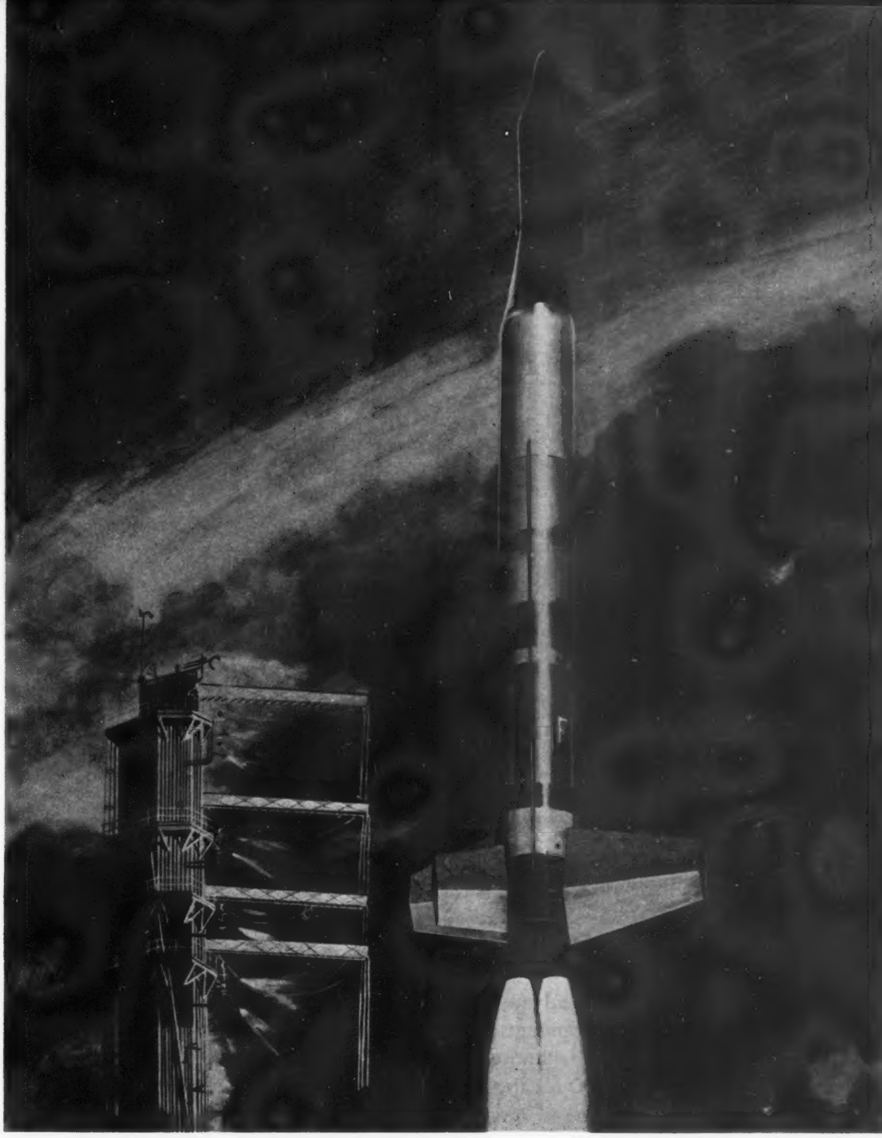
It is proposed to give the final impulse to transfer the 24-hr satellite from the high-altitude waiting ellipse into the 24-hr orbit by the positioning system of the satellite, which will be separated from the third booster stage after its injection into the high-altitude ellipse. Thus, the inertial-guidance system now has to operate only until the apex impulse at the end of the Hohmann transfer ellipse has been applied. The scheme described leads to a minimum operating time for the inertial guidance system of about $6^1/_2$ hr after launch and to a minimum of corrections for circularization by the satellite positioning system.

The illustration at bottom shows the projection of a flight path with high-altitude looping onto the earth's surface for a geostationary point at 45 deg West. The chart on page 68 exhibits the minimum number of loops and the parking orbit departure node as a function of the desired injection longitude for a restricted apogee velocity increment of 100 meters per second.

As described, the high-altitude looping scheme needs only two main injections, or twice a re-ignition of the third booster stage. The predictable impulse for circularization, or the third and final injection, will be applied together (CONTINUED ON PAGE 68)



Geostationary Orbit Injection by High-Altitude Looping



ARS Specialist Conference Report

LIFTING RE-ENTRY VEHICLES

APRIL 4-6, 1961
Riviera Hotel, Palm Springs, Calif.

Re-entry from super-orbits indicates possible use of new configurations, need for materials, structures, and thermal-protection systems in 4000-6000 F range . . . Radiation heating a problem . . . Absorptive systems such as pyrolitic graphite and modified chromium appear promising

By Edwin G. Czarnecki
MANAGER, STRUCTURES TECHNOLOGY DEPT., BOEING CO., SEATTLE, WASH.

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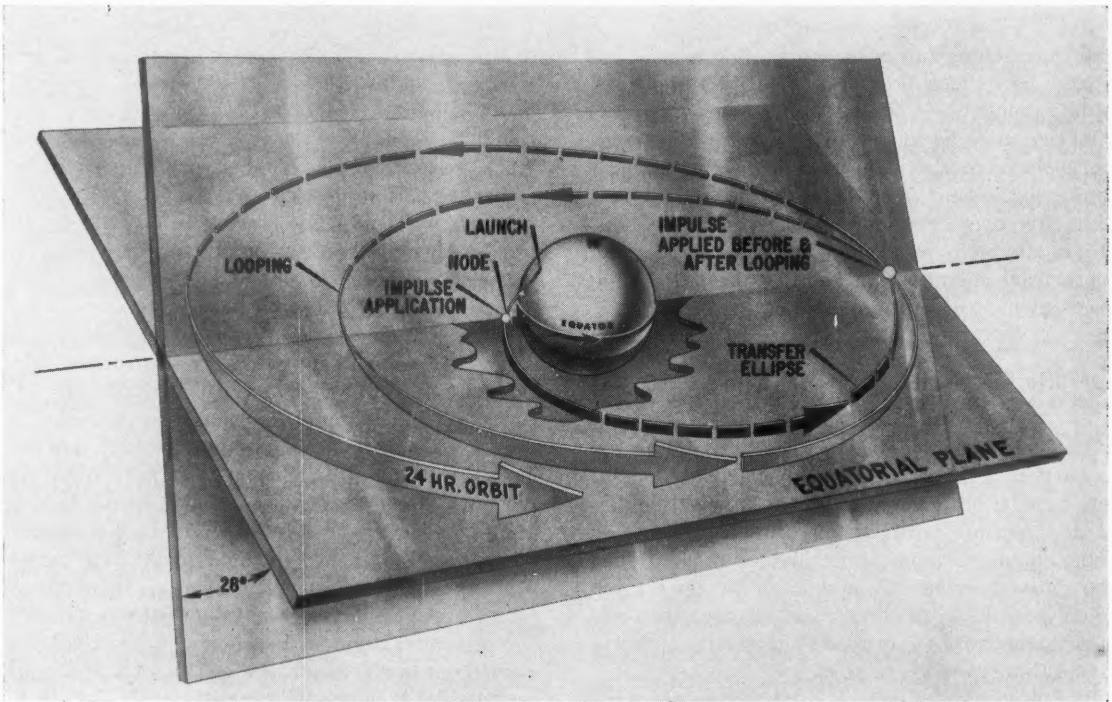

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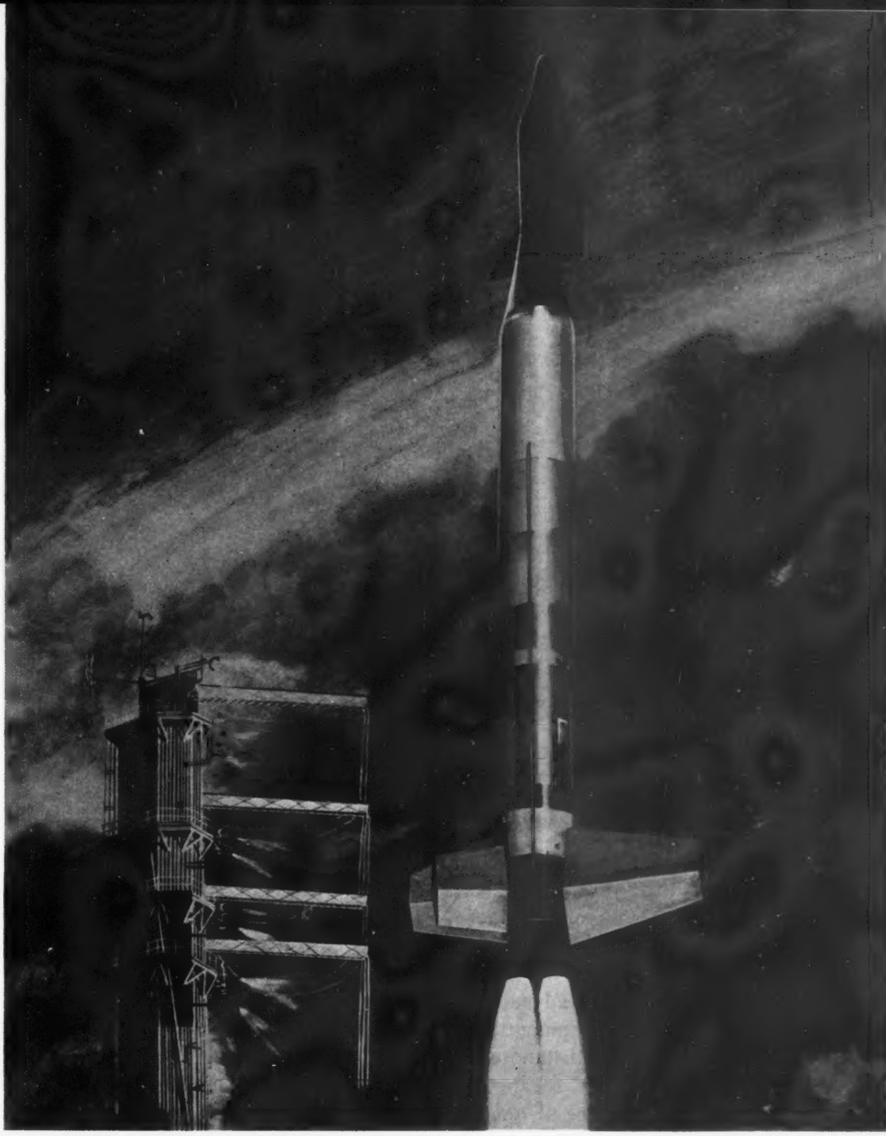

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By Edwin G. Czarnecki
MANAGER, STRUCTURES TECHNOLOGY DEPT., BOEING CO., SEATTLE, WASH.

LIFTING RE-ENTRY VEHICLES

Edwin G. Czarnecki (left) of Boeing Co., Conference Chairman, poses with George Gerard of NYU, Chairman, ARS Structures and Materials Committee.

Informality marked Boeing-sponsored reception, as indicated in this poolside shot of (left to right) Martin A. Kinsler of North American, Lloyd Kaechele of Rand Corp., Mrs. Max L. Williams, and George A. Hoffman of Rand.

THE SECOND ANNUAL ARS Structures and Materials Specialist Conference, devoted this year to the subject of Lifting Re-Entry Vehicles, and held April 4–6 at the Riviera Hotel in Palm Springs, Calif., was marked by reports of significant advances in the state-of-the-art, especially in development of materials and structures capable of withstanding anticipated temperatures in the 4000–6000 F range.

The meeting, which drew an attendance of more than 360, proceeded in logical fashion from an examination of the design criteria for lifting re-entry vehicles and environmental factors, through discussions of new materials, thermo-structural analytical techniques, and thermal-protection systems, to a final Classified (Secret) session on vehicle design, concerned with integration of these various elements into specific solutions for several different cases, and particularly with Dynasoar, the first U.S. lifting re-entry vehicle.

The first session, devoted to Design Criteria, was planned to review some of the factors bearing on lifting re-entry vehicle design and to stimulate interest in design problems. Since design ideas are not as yet fixed, the papers at this session were specifically aimed at the development of information which would lead to proper design of such vehicles —in effect, to set up the ground rules for future re-entry vehicle programs.

The lead-off paper at the session was an invited paper by Alfred J. Eggers and Thomas J. Wong of NASA's Ames Research Center on "Motion and Heating during Atmosphere Entry" (ARS Preprint No. 1675–61), which keynoted the entire meeting. The paper, delivered by Dr. Eggers, held a capacity audience enthralled for an hour and a half and, in the opinion of those in attendance, is destined to become a classic in its field. The paper provided a detailed summary of current knowledge about the re-entry problem in general and the problem of superorbital re-entry in particular, and suggested several fruitful areas of research.

Data Needed on Radiative Heating

In running down these problems, Dr. Eggers noted that radiation heating may be a factor in supersatellite re-entry, pointing out that maximum radiative heating rates for parabolic re-entry tend to occur during the descent in the first graze, and overlap the region of maximum convective heating rates, as shown in the graph on page 30. He added that there is a dearth of experimental data on equilibrium radiation heating at supersatellite speeds and that our knowledge of nonequilibrium radiation heating is only now beginning to develop at both subsatellite and supersatellite speeds.

Radiation heating, he went on, demonstrates perhaps the most pronounced tendency to increase in intensity with increasing speed, and may in fact tend

Left to right, James Taylor of the Royal Aeronautical Establishment, Farnborough, England; Mrs. and Dr. Max L. Williams, and Mrs. and Mr. George Mangurian of Northrop.

Courtland D. Perkins, Banquet speaker, (second from right) poses with M. A. Steinberg of Lockheed, Edwin G. Czarnecki, and Harry Goldie of Boeing at reception.

to dominate the heating problem during hyperbolic re-entry. In this event, less blunt shapes may be required than those which derive from considerations of convective heating alone.

In the area of re-entry configurations, Dr. Eggers commented, both fixed and variable geometry types may have applications. However, the primary need now and for some time to come lies in the area of detailed aerodynamic and heating data on typical configurations with suitable controls. Such controls also present problems, he said, since they may encounter especially severe heating when extended to perform sharp maneuvers or to increase drag sizably.

The second session, dealing with Environmental Factors, took up the question of the types of conditions which are encountered once the ground rules for lifting re-entry have been established. It immediately becomes apparent that extremely high temperatures will be experienced—of the order of 4000–6000 F, rather than the 3000–4000 F range being studied under presently funded programs. In addition, the problems involved in water impact and shielding also come under close scrutiny.

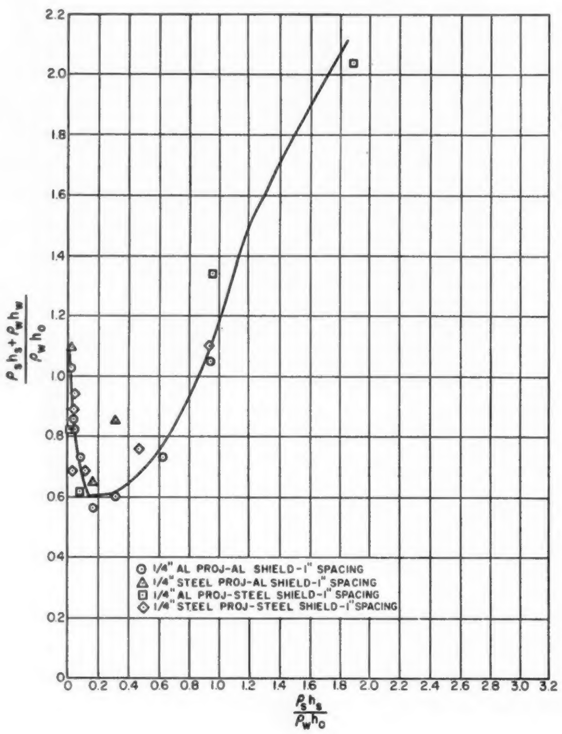
William H. Mueller and James L. Malakoff of Grumman, in their paper on "Water Impact of Manned Spacecraft" (1680–61), indicated that, while the sea is a hostile environment for lifting re-entry vehicles, rough water landings appear to be humanly tolerable for vehicles with no auxiliary landing devices following a parachute descent. They added that if, either through chance or controllability, impact occurs in a following sea or at a better position in an oncoming sea, or parallel to a wave crest in smooth water, impact load factors and onset rates are reduced.

Water Impact Rough

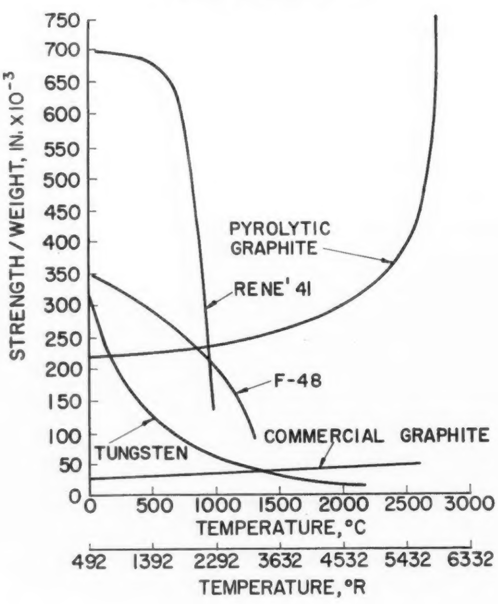
Controllability seems possible with the lifting glider configuration, they noted, although two basic items must be considered when analyzing water impact in rough seas. The first is that landing devices must be utilized to minimize the impact load factor, and the second that some stabilizing components must be found which would restrict, or, preferably, eliminate, rebound. Impacts with deep plunging penetrations are also worthy of consideration, they concluded.

In a paper on "Effects of Hypervelocity Particles on Shielded Structures" (1683–61), R. R. Wallace Jr., J. R. Vinson, and M. Kornhauser of GE-MSVD discussed a test program in which over 300 hypervelocity projectiles of different sizes and materials, and moving at different velocities, had been fired at structural walls protected by single shields of varying materials, thicknesses, and shield-to-wall spacing. The tests revealed that in these structures about 50% of over-all structural weight can be saved by proper design and use of meteor bumpers

Typical Weight Savings Made Possible by Shielded Structure



Strength-to-Weight Ratio vs. Temperature for Various Materials



without sacrifice of safety (see graph at left). In short, the Whipple shield concept proved to be highly effective in the MSVD test program.

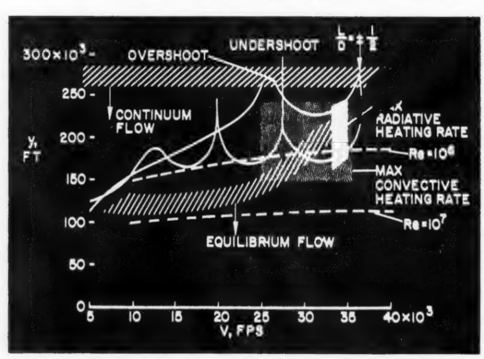
The authors noted that, of the materials considered, steel shields were always better than either aluminum or magnesium, while aluminum shields proved better than magnesium for 70% of the shots fired using these materials. Beryllium also appears to be a possibility because of its high modulus of elasticity and relatively low density. While no definite conclusions could be drawn with respect to shield spacing, the 1/4-in. spacing was always least effective, with 3/4-in. spacing resulting in minimum penetration under nearly all conditions. The 0.215-in. shield thickness generally seemed most efficient, followed by the 0.063-in. thick type, although the lack of strong statistical significance for varying shield thicknesses was attributed to the fact that thickness seems to interact with shield material, spacing, etc. It is expected that even thinner shields may be optimum for higher impact velocities.

While it proved impossible to duplicate accelerations of discrete particles in the meteoroid velocity range of 11 to 73 km/sec, and suitable scaling laws have not been established, the authors commented that there is reason to believe effectiveness of meteor bumpers would probably increase at such velocities.

The next session, devoted to Materials, produced one of the most interesting papers presented at the meeting—on "Modified Chromium for Unprotected Structures Over 2600 F" (1688–61) by D. M. Scruggs of Bendix Products Div.—which reported on the fact that one brittle material (chromium) had been added to another brittle material (ceramic) to produce a ductile material of great promise. This one had people walking around shaking their heads.

In his paper, the author noted that two problems which have prevented the use of chromium as an engineering material in the past decade had been essentially solved. The first of these was that massive chromium had never been made ductile at

Flow and Heating Domains



Physical Differences Between Pure and Modified Chromium

	Chromium	Modified Chromium
Strength	Low	Higher
Oxidation	Good - scales	Better - resists scaling
Weight	0.26#/cu.in.	0.238#/cu.in.
Machineability	Poor - surface galls	Good - smooth surface
Room Temperature Ductility	Only in ultra pure chromium	Present in extruded material
Ductility after High Temperatures	Disappears	Retains ductility
Workability	Requires cladding special technique	Forged, extruded, and rolled unprotected

room temperature and the second that very pure chromium embrittled completely after high-temperature exposure of any duration. Scruggs stated that research in extruded material at extrusion ratios of 10:1 and higher have produced chromium which is ductile in tension and bending at room temperature. Other advantages are indicated in the chart above.

Modified Chromium Interesting

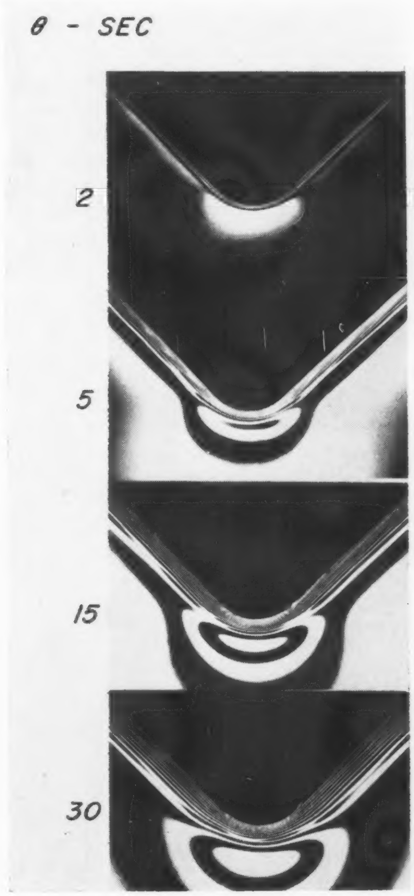
The Bendix research program, Scruggs indicated, showed that modified chromium has sufficient strength, erosion resistance, and ductility to operate in glide re-entry vehicles as various metallic components in the 2000–2600 F range. As lightly loaded heat shielding, he went on, it can operate at temperatures which melt normal "superalloys"—2600 F and above. He pointed to modified chromium as a successful example of a material designed and developed to operate in a specific system requirement, as well as one which could be useful in the solution of many high-temperature structural problems.

The Materials session also indicated quite clearly that an oxidation problem exists at high temperatures, and that new oxidation coatings will be required.

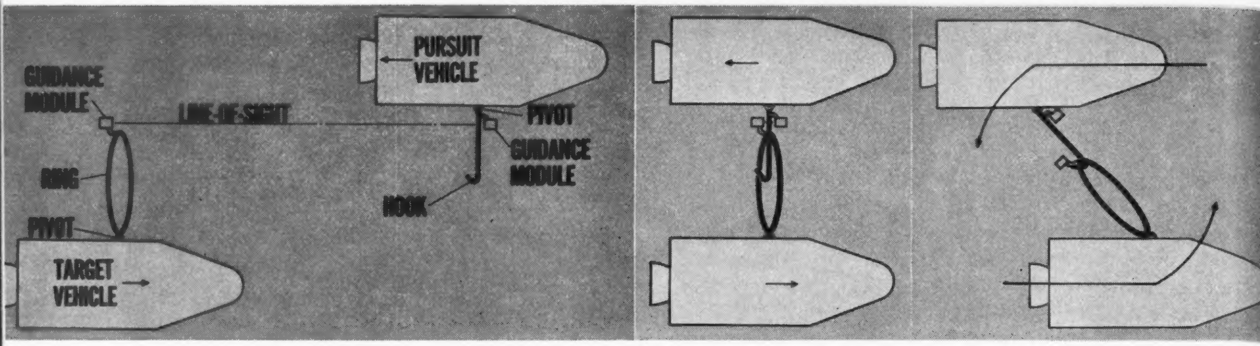
The following session, devoted to Thermo-Structural Analysis, indicated that considerable progress has been made in the development of tools which can be used to handle thermal stress problems. Papers at the session revealed greater maturity in analytical methods, and showed that important factors are being recognized (CONTINUED ON PAGE 50)

Notch Fringe Patterns as Functions of Time

(Right-angle notch with 1/4-in. fillet radius)



Final Closing and Coupling Maneuvers



Guided Closure   Engagement   Path Transition

Satrac—space rendezvous system

This interesting design features optical guidance and control to make a maneuver expected to play a key part in space operations

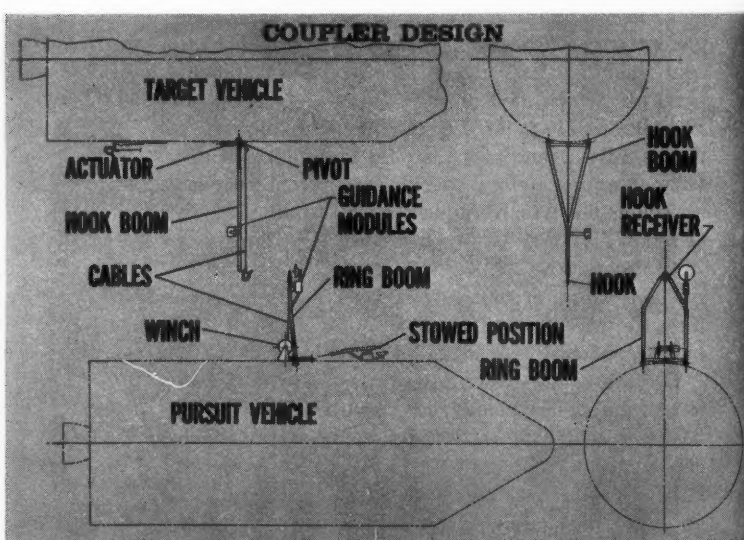
By Lawrence J. Kamm

CONVAIR-ASTRONAUTICS, SAN DIEGO, CALIF.

Lawrence J. Kamm is a design specialist at Convair-Astronautics, working in the field of space vehicles. Since receiving a B.S. in electrical engineering from Columbia Univ. in 1941 (also an M.E.E. from Polytechnic Institute of Brooklyn in 1946), he has worked on electromechanical devices and systems, including numerical controls for machine tools, computer devices, instruments and transducers, a mail-sorting machine, the Decimal-Keeper slide rule, relays, a heart-lung machine, and satellite systems and components. In such areas 14 patents have been issued to him and six more are pending. Kamm is a licensed professional engineer in New York, Maryland, and California, and is a registered patent agent.

RENDEZVOUS and coupling of "friendly" satellites will be a valuable maneuver in the development of the space art. It will be used for both ferrying between space stations and earth and for assembling space stations and very large rockets in orbit. It may also be used for refueling existing rockets to increase their capability.

If the maneuver is fully automatic, then it is unnecessary to incur



the weight, complexity, and risk of providing a pilot. Even where an assembly is to be manned, the crew can be boosted on the last launch instead of on the first or second, thereby enhancing over-all safety and reducing the crew's time in space.

Granted the operational value of rendezvous (see Kurt Stehling's article in the April 1961 *Astronautics*), what might a practical system be like? Some of our ideas are embodied in the system known as Satrac (for "satellite automatic terminal rendezvous and coupling"), which is described here.

Satrac comprises an optical-homing guidance system and a coupling mechanism to join cooperative satellites. The guidance is for the terminal phase with typical initial conditions of 50 mi. distance and 2000-fps relative velocity.

Maneuvering Target Vehicle

The first vehicle in orbit, referred to as the target vehicle, cooperates by orienting, by exhibiting a target lamp, and by carrying half of the coupling device. The lamp emits pulsating light to distinguish it from the stars. This vehicle does no accelerating.

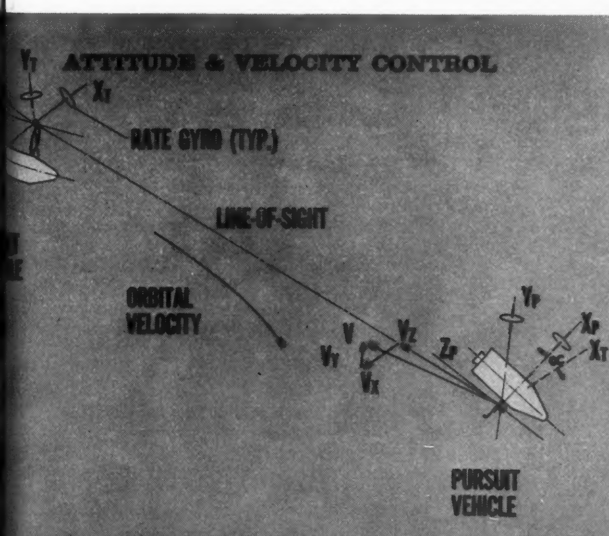
The second vehicle launched, referred to as the pursuit vehicle, also orients, exhibits a lamp to guide the target vehicle orientation, and carries the other half of the coupling device. In addition, it accelerates to reduce the distance and relative velocity. cantilever arms, shown at bottom on page 32, illustrates the final closing and coupling of the vehicles. Each vehicle has an optical-guidance module on a boom extending from its side. Each module seeks the other vehicle's module, i.e., each module's telescope seeks the other module's lamp and commands its own vehicle to turn with it. Thus the guidance modules close along the line of sight and the vehicle bodies close on offset paths separated by the length of the two guidance-module booms.

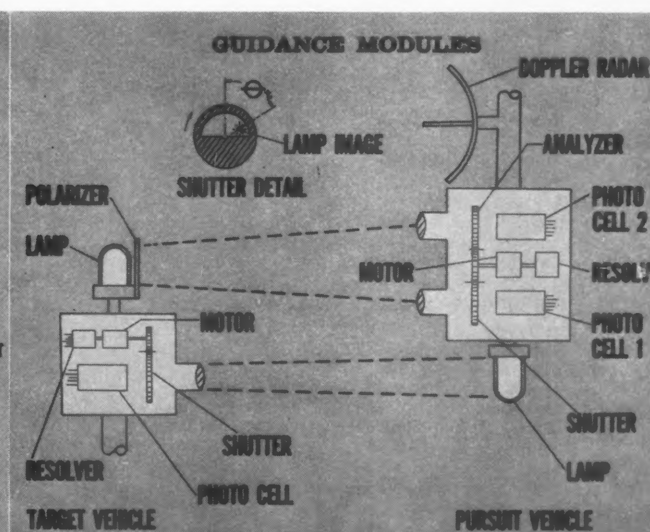
One vehicle's coupler has a ringlike form and the other coupler has a hooklike form. If there is no guidance error, the guidance modules are aligned and the hook enters the center of the ring. The radius of the ring is the allowable guidance error. Since the diameters of the lamps and telescopes are a few inches and the diameter of the ring is several feet, static error in the guidance system is negligible, and the ring size is provided to accommodate dynamic error.

As the vehicle bodies pass, the hook boom and ring strike, pivot with the vehicle motion, and slide over each other until the hook latches to the ring. The vehicles begin a slow pinwheeling motion under centripetal tension in the coupler. The hook and ring, which in fact are flexible cables supported on cantilever arms, shown at bottom on page 32, are then winched into the pursuit vehicle to draw the two vehicles together. Attitude-control rockets reduce the pinwheeling rate to zero.

Because there is no headon docking, it is unnecessary to reduce range and range-rate to zero simultaneously. In fact, range is not even measured when the vehicles are close. Instead range rate is reduced to approximately 1 fps at some substantial distance, left there, and the vehicles engage at this speed. Because of the offset path, there is no damaging collision.

At the start of the pinwheeling phase each vehicle is angularly accelerated to the pinwheel rate of rotation. Without damping (CONTINUED ON PAGE 44)





Status of the ion-propulsion effort

New and revised contracts give a picture of the fast-growing and increasingly important field of electrostatic propulsion

By Eugene Urban, Research Projects Div. Staff
NASA MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALA.

THESE tables give the status of ion-propulsion research and development sponsored by various government groups as of April 1, 1961. The tables revise and bring up to date the information presented in "The U.S. Ion-Propulsion Program" by Hayes, Seitz, and Stuhlinger in the January 1961 *Astronautics.*

The ion-propulsion program continues to grow in importance. J. W. Stearns of the Jet Propulsion Laboratory of the California Institute of Technology makes this comment concerning present interest in electric propulsion in his paper on applications (ARS Preprint 1751–61) given at the ARS Space-Nuclear Conference, held last month at the Oak Ridge National Laboratory:

"Through a study and evaluation of industrial efforts and progress in the field of electric propulsion, the Jet Propulsion Laboratory has reached the conclusion that spacecraft with nuclear-electric propulsion can be used advantageously to perform planetary and interplanetary missions during the latter half of this decade. . . Prototypes capable of meeting the minimum requirements should become available within the next few years. . . Certain highly desirable missions can be achieved only through the use of the electrical propulsion system." ♦♦

COMPLETED CONTRACTS, ION PROPULSION

Contractor and Project Managers	Source	Contract Number	Amount ($Millions)	Duration (Months)	Started	Remarks
EOS						
(Naiditch)	ABMA (ARPA)	DA 04-495-ORD 1191 (Part I)	$0.319	28	March 1958	Investigation of ionized gases
(Naiditch)	ABMA (ARPA)	DA 04-495-ORD 1191 (Part III)	.189	16	March 1959	Acceleration systems for ion propulsion
General Electric						
(Edwards)	ABMA	DA 33-008 ORD-1839	.155	14	June 1959	Ion engine performance evaluation
(Edwards)	NASA	NAS 8-29	.015	3	Aug. 1960	Ion engine performance evaluation
GHVA						
(Gale)	ABMA	DA 12-020-ORD-4969	.085	14	June 1959	Ion thrust devices (duoplasmatron)
Marquardt						
(Pitkin)	ARL	AF 33(616)-6844	.025	6	Oct. 1959	Sputtering, secondary emission, computer beam studies
Rocketdyne						
(Boden)	AFOSR	AF 49(638)-16	.045	12	Jan. 1957	
(Boden)	AFOSR	AF 49(638)-344	.090	12	March 1958	Analytical study of ion propulsion
(Boden)	AFOSR	AF 49(638)-351	.193	24	July 1958	Ion-propulsion research
(Boden)	AFOSR	AF 49(638)-649	.100	12	Feb. 1959	
TRW						
(Fairweather)	WADD (ARPA)	AF 33(616)-5919	.671	24	July 1958	Mission and experimental studies
(Krohn)	ARL	AF 33(616)-6775	.137	18	Aug. 1959	Basic studies of charged droplets of liquid Wood's Metal

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STATUS OF THE ION-PROPULSION EFFORT, AS OF APRIL 1, 1961

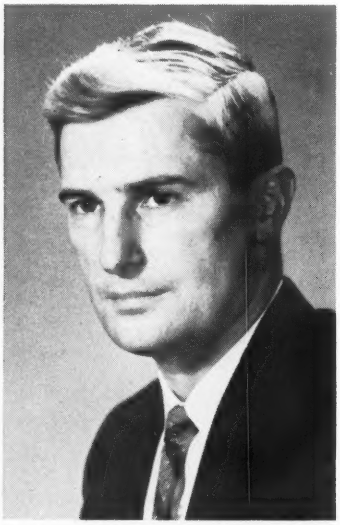
Contractor and Project Managers	Source	Contract Number	Amount ($Millions)	Duration (Months)	Started	Remarks
Aerojet-General						
(Edmonson)	AFOSR	AF49(638)-656	$0.170	22	May 1959	Charged oil droplet formation
(Sunderland)	AFOSR	AF49(638)-214	.270	36	May 1958	Hohlraum source
Allison						
(Rosebrock)	In-house effort					Theoretical analysis
Convair	In-house effort					Duoplasmatron, theoretical analysis, sputtering
EOS						
(Forrester)	WADD (ARPA)	AF33(616)-6958	1.190	15	Feb. 1960	Alkali metal ion engine. Classified objectives
(Teem)	NASA	NAS 5-604	.084	8	Sept. 1960	Negative ion sources
(Toms)	NASA	NAS 8-1545	.044	6	March 1961	Ion engine flight test objectives study
(Teem)	NASA	NAS 8-1537	.077	8	Feb. 1961	Surface ionization
(Speiser)	ONR	?	.070	12	Nov. 1960	Cesium ion-atom scattering
General Electric						
(Edwards)	NASA	NAS 8-623	.043	12	Nov. 1960	Computer evaluation of ion engine configurations
(Stauffer)	NASA	NAS 8-624	.043	12	Nov. 1960	Electrical conduction in cesium vapor
GHVA						
(Nablo)	WADD	AF 33(616)7178	.280	12	April 1960	Duoplasmatron. Classified objectives
(Nablo)	NASA	NAS 8-858	.026	8	Dec. 1960	Duoplasmatron cathode development
Hughes Aircraft						
(Currie)	NASA	NAS 5-517	.811	19	Oct. 1960	Alkali metal ion engine. Classified objectives
Martin	In-house effort					Theoretical analysis
NASA Lewis						
(Childs, Kaufman)	In-house effort					General ion engine R&D; bombardment type of ion engine
RCA (Montreal)						
(Cloutier)	WADD	AF 33(616)-7437	.040	12	May 1960	Negative ions (SF_6)
Reaction Motors						
(Wolfhard)	AFOSR	AF 49(638)-657	.215	18	May 1959	Behavior of metallic dust during charging process
Rocketdyne						
(McDole)	WADD	AF 33(616)-7622	.100	12	Oct. 1960	Electrostatic acceleration
(McDole)	WADD	AF 33(616)-5927	.253	36	June 1958	Study of high current density ion sources
(Cox)	WADD	AF 33(616)-7063	.184	18	March 1960	Production of colloids and negative ions
SRI						
(Kino)	NASA	NAS 8-1509	.050	12	Feb. 1961	Space charge flow
STL						
(Langmuir)	NASA	NAS 8-41	.097	12	Oct. 1960	Porous tungsten ion emitters
(Langmuir)	NASA	NAS 8-1560	.087	6	March 1961	Beam diagnostics
(Langmuir)	AFOSR	AF 49(638)-886	.092	12	May 1960	General neutralization studies
TRW						
(Snoke)	WADD	AF 33(616)-7219	.145	13	March 1960	Ion propellant feed system
(French)	NASA	NAS 8-42	.086	12	Oct. 1960	Annular duoplasmatron
United Aircraft						
(Meyerand)	WADD	AF 33(616)-7448	.094	12	July 1960	Penning source, general research
(Edelbaum)	NASA	NAS 5-935	.097	12	Feb. 1961	Ion engine mission studies,
Univ. of Ala.						
(Mann)	NASA	NAS 8-1503	.053	12	Jan. 1961	Theoretical neutralization studies

Response to the "Panama Hypothesis"

Do the claims of this hypothesis, which projects international rivalry and a desire for dominion into space, draw the support of the U.S. astronautical community?

By Dandridge Cole

GE MISSILE AND SPACE VEHICLE DEPT., PHILADELPHIA, PENN.



Dandridge M. Cole, a consulting astronautical engineer, is a space-programs analyst for GE MSVD, having joined the company in Oct. 1960. He previously was a senior advanced planning specialist for Martin-Denver's staff. After receiving an A.B. in chemistry from Princeton Univ. in 1943, he taught and studied until 1953, in the interim also receiving an M.A. in physics from the Univ. of Pennsylvania. Joining Martin-Denver in 1953, he served variously as an armament-analysis, operations, and design engineer on a variety of rocket and missile systems until 1957. He worked on the conceptual design of a nuclear pulse rocket as early as 1956. He is a past president of ARS Central Colorado Section.

THE RECENT breakthrough in manned space flight has once again focused world attention on the Russian lead in space boosters and payload weights. No one can deny the present Russian superiority in these aspects of space exploration, but some question the long-range value of large payload weights, of men in space, and of any space race with Russia. Perhaps we will want to go into space ultimately, it is said, but what is the hurry?

To date, only one reason for urgency in our space program has been adequately presented and has achieved any general acceptance; that is the issue of national prestige. While this reason alone is cause for concern, there are other reasons which may have even greater impact on our national future. One such reason—the "Panama Hypothesis"—will be discussed here.

The Panama Hypothesis can be summarized in this statement: *There are strategic areas in space—vital to future scientific, military, and commercial space programs—which must be occupied by the United States, lest their use be forever denied us through prior occupation by unfriendly powers.*

A questionnaire has been designed to investigate the degree of acceptance of this belief by the astronautics profession. It has been sent to 89 National and Section officers of the ARS and 75 officials of the National Aeronautics and Space Administration. It was also distributed to ARS University Park Section members.

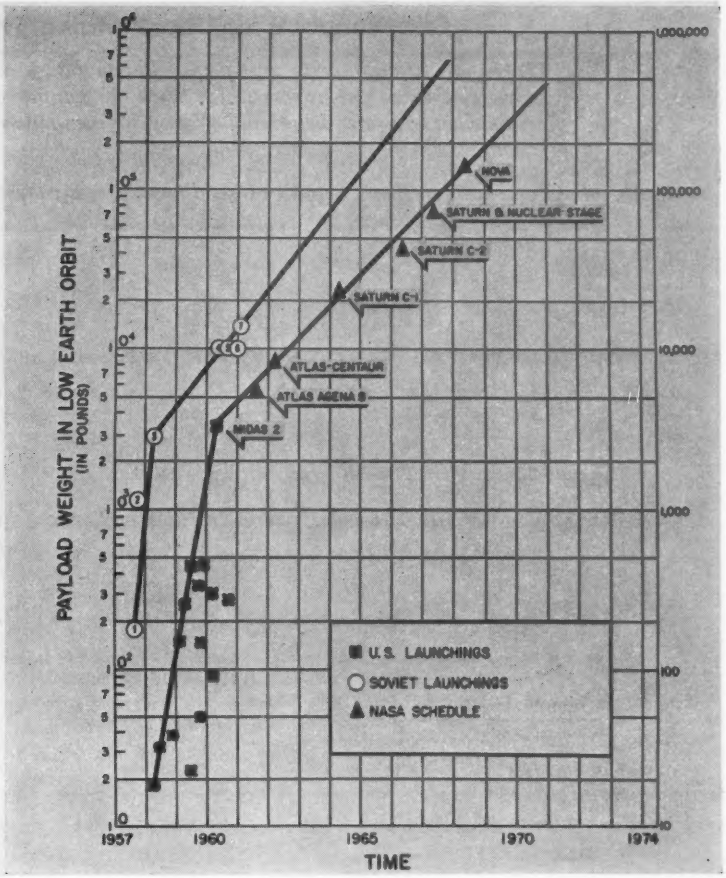
Urgency In Our Space Program

The primary purpose of this survey is to stimulate thought and discussion on reasons for urgency in our space program. It may also have some value in determining professional attitudes toward certain key questions relating to the future of manned space flight.

The results of the survey will be presented after a short discussion of the space booster gap and some of the basic factors affecting the Panama Hypothesis.

The fact that Russia leads the U.S. in rocket-engine thrust has been known to a few since 1947, to many since 1955, and to all since

Comparison of Trends in U.S. and Russian Space Payload Capabilities



1957. However, it is still not clear to more than a handful that *the gap is not closing, but widening,* and that it is imperative that this gap be closed no later than the 1965–1967 period.

The NASA Space Program, as presented in early 1960, was advertised as one which would overtake the Russian lead and provide us with a capability for putting greater payloads in space than those of the Russians. The previous NASA Administrator, T. Keith Glennan, stated last year that we would catch the Russians by 1965.

The graph above compares the Russian satellite launchings and high-performance U.S. launchings. It also indicates some key performance figures from the NASA schedule and a possible extrapolation of the established trend in Russian launchings. Note that the Russian curve is based on actual launchings.

Of course, we do not *know* what advances in payload capability will be made by the Russians in the future. It is possible that their performance curve will level off sufficiently to strike the NASA schedule line in about 1967, but this would be an extremely optimistic interpretation of the data. *Note that this graph was originally prepared in June 1960* and that Sputnik 7 confirms exactly the straight line growth curve through Sputniks 3 and 4. It may be reasonable to discount Sputniks 1 and 2 as merely practice shots with the Sputnik 3 booster. Sputniks 8, 9, 10, and 11 have not been added since they do not change the curve.

Russia has stated an intention to land a man on the moon in 1967. To do this, it would be reasonable to assume a program leading to a Nova-like vehicle in 1965. The curve indicates a capability for placing 100,000 lb in orbit by the end of 1964. It should be emphasized that Russia has had a lead of about 2 yr over the U.S. in rocket-engine thrust ever since 1947, and that this lead presumably exists even in early development programs at the present time. There were many reports of test firings of single-barrel engines in excess of 1-million-lb thrust more than 2 yr in advance of the first tests of the Rocketdyne F-1 1.5-million-lb-thrust engine.

If the NASA schedule of 1960 represented an orderly, step-by-step development, which leads naturally to the illustrated logarithmic growth in capability, is not a similar, parallel growth curve, based on an earlier start and a greater present

Questionnaire on the Panama Hypothesis

"There are strategic areas in space—vital to future scientific, military, and commercial space programs—which must be occupied by the United States, lest their use be forever denied us through prior occupation by unfriendly powers."

1) *Does the Panama Hypothesis represent a good reason for acceleration of our space program?*

☐ *yes* ☐ *no*

2) *What is the probability that it is correct?*

Check your estimate below. Note that "Certainly false" indicates a probability of less than 10% while "Certainly true" means more than 90% probable.

☐ *Certainly false* ☐ *Probably false* ☐ *50-50* ☐ *Probably true* ☐ *Certainly true*

3) *What is the probability that each separate condition will be confirmed?*

a) Man can learn to live and work beyond the Van Allen belts—with artificial protection.

☐ *Certainly false* ☐ *Probably false* ☐ *50-50* ☐ *Probably true* ☐ *Certainly true*

b) The cost of transporting payloads to the surface of the moon will eventually (within 50 years) drop to 100 dollars per pound or less (1960 dollars)

☐ *Certainly false* ☐ *Probably false* ☐ *50-50* ☐ *Probably true* ☐ *Certainly true*

c) At least one strong reason will eventually develop (50 years) for bases on the moon and the nearer planets.

☐ *Certainly false* ☐ *Probably false* ☐ *50-50* ☐ *Probably true* ☐ *Certainly true*

d) The moon will prove to be similar to the earth in having areas of widely different value and desirability, such that a nation in possession of the more highly favored areas would have a decisive competitive advantage in future scientific, military, or commercial activity in space.

☐ *Certainly false* ☐ *Probably false* ☐ *50-50* ☐ *Probably true* ☐ *Certainly true*

4) *A possible fifth condition has been assumed—that Russia would in fact take possession of critical areas, if in a position to do so, and exclude us from their use. If this also is assigned a probability what is your estimate?*

☐ *Certainly false* ☐ *Probably false* ☐ *50-50* ☐ *Probably true* ☐ *Certainly true*

5) *If there is some other condition which should be included or some weakness in the theory not covered by the conditions, please comment below or on reverse side.*

____

____

The results of this questionnaire will be reported in a statistical manner only. Answering the questions does not constitute permission to publish individual responses. Forms need not be signed. A report on the questionnaire results will be sent to all participants.

Panama Hypothesis Questionnaire Results

Area	Group	Yes	No	De-batable	% of Those Answer-ing Who Say Yes	Num-ber Polled	Num-ber Replied
(1)	ARS Officers	27	2	1	93	89	30
	Univ. Park	29	3		91	32	32
Good reason for	Total ARS	56	5	1	92	121	62
urgency	NASA	13	7		65	75	20

Area	Group	Cer-tainly False	Prob-ably False	50-50	Prob-ably True	Cer-tainly True	% of Aver-age Prob-ability
(2)	ARS Officers	1		4	20	5	73
	Univ. Park	1		2	20	9	77
Panama Theory is	Total ARS	2		6	40	14	75
correct	NASA		7	3	8	2	56
(3-a)	ARS Officers			3	10	17	84
	Univ. Park			3	8	21	86
Life in space	Total ARS			6	18	36	85
	NASA			1	10	9	83
(3-b)	ARS Officers		1	7	13	9	74
Cost	Univ. Park			7	15	10	76
	Total ARS		1	14	38	19	75
	NASA		2	2	12	3	70
(3-c)	ARS Officers			3	15	12	81
Need	Univ. Park		1	1	13	17	83
	Total ARS		1	4	28	29	82
	NASA		2	1	10	7	76
(3-d)	ARS Officers			2	17	11	81
Preferred areas	Univ. Park		2	3	19	8	75
	Total ARS		2	5	36	19	78
	NASA		3	2	12	3	68
(4)	ARS Officers		1	1	11	17	84
International com-	Univ. Park			3	15	14	82
petition	Total ARS		1	4	26	31	83
	NASA	1	5	6	5	3	55

capability, the most reasonable estimate of the future Russian program?

It is of interest to note the sharp break in the U.S. curve at Midas II. Most of the high-performance launchings prior to Midas II were made by the military services, while the less-impressive future schedule is that of the civilian agency. Has the delegation of responsibility for future space exploration to a civilian agency instead of the Armed Forces resulted in a fatal break in our normal logarithmic growth curve? Would the military have been likely to follow-through with the original off-the-shelf Saturn program (Titan for Stages II and III) and launched a 20,000-lb payload into orbit in mid-'61? If so, they would not only have stayed on the original U.S. logarithmic growth curve but would have crossed the Russian curve at that point.

(CONTINUED ON PAGE 76)

Space Flight Report to the Nation Interim Report

Doolittle, Ehricke, Kantrowitz To chair SFRN panels

Discussions at ARS Coliseum meeting will assess space vehicles, space missions, and global aspects of space flight

THREE distinguished moderators will head the SPACE FLIGHT REPORT panels being organized for the ARS SPACE FLIGHT REPORT TO THE NATION to be held at the New York Coliseum, October 9–15, 1961. The announcement was made recently by the organizer of the panels, Jerry Grey of Princeton University's Forrestal Research Center. The moderators of the three SPACE FLIGHT REPORT panels will be—

The Vehicles: Krafft Ehricke, director, Project Centaur, Convair-Astronautics.

The Missions: Arthur R. Kantrowitz, vice-president, Avco Corp., and director, Avco-Everett Research Laboratory.

Global Effects: James Doolittle, chairman of the board, Space Technology Laboratories, Inc.

Wernher von Braun, chairman of the SPACE FLIGHT REPORT TO THE NATION Committee, underscored the importance of the SPACE FLIGHT REPORTS by calling the panels "a rare opportunity afforded the space-flight community to view the entire national space effort in perspective."

To accommodate maximum audiences, the panels have been scheduled not to conflict with any of the 44 technical sessions to be held during the week.

Top experts from each of the areas listed will present the implications, both technical and philosophical, in a five-minute formal talk. The preliminary talks will be followed by a one-hour panel discussion and a one-hour floor discussion. ♦♦

SPACE FLIGHT REPORT

The Vehicles

Moderator: Krafft Ehricke

Vehicle Systems
Chemical Propulsion
Advanced Propulsion
Guidance and Control
Ground Support

Special Vehicle Problems

SPACE FLIGHT REPORT

The Missions

Moderator: A. R. Kantrowitz

Sounding Rockets and Scientific Satellites

Solar System Exploration
Meteorological Applications
Communications Applications

Manned Space Flight

SPACE FLIGHT REPORT

The Global Effects

Moderator: James Doolittle

Military Effects
Political Effects
Sociological Effects
Industrial-Economic Effects
Communication and Human Relations
Extraterrestrial Contact

ARS Space Flight Report to the Nation

OCTOBER 9—15, 1961

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Miss Sylvia Peltonen, Secretary
ARS Housing Committee
90 East 42 Street
New York 17, N. Y.

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2nd				
3rd				
4th				
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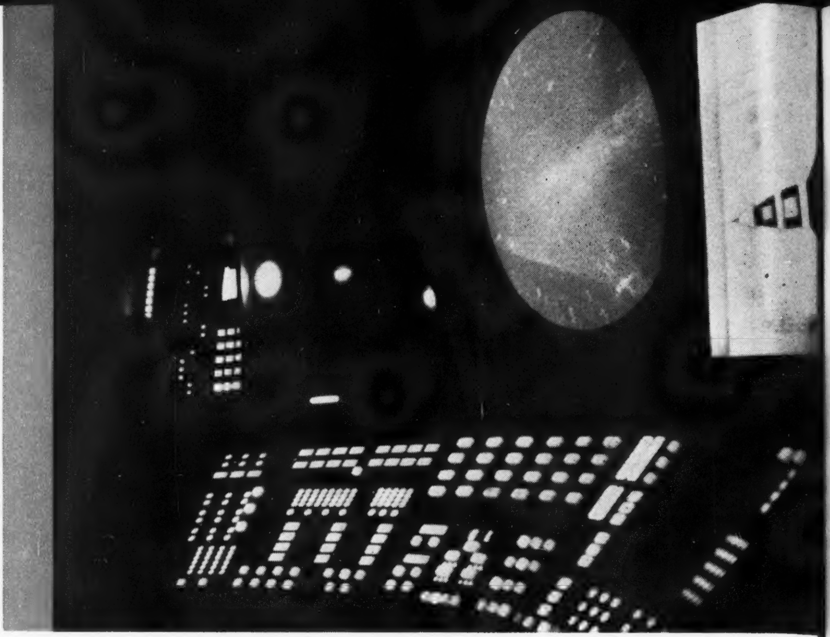
Lunar flight control display



This systems-engineering model gives a graphic sense of the necessary flight controls for major space missions

By T. E. Garrigan

SPERRY GYROSCOPE CO., GREAT NECK, N.Y.

THE FLIGHT engineer on a lunar transport will be an important member of the crew. Although the pilot will be in control of the vehicle, the flight engineer will be responsible for monitoring and maintaining all of the vehicle's vital systems; and although equipment undoubtedly would be designed to react automatically to emergency situations, the engineer must be presented with an instantaneously updated status-reaction display to permit override control and increased reliability.

The possible nature and arrangement of a space engineer's instruments and displays is demonstrated by a full-scale mockup recently designed and constructed at Sperry Gyroscope to illustrate the possible relationship between man and his instruments in future space vehicles.

Two Operating Positions

The mockup was designed with a vehicle crew of four in mind. The ship was assumed to have two operating positions, pilot and flight engineer. The pilot would monitor the flight of the vehicle, which was assumed to be ground-controlled during injection, program-controlled during free flight, and terminally guided during landing. The pilot would have controls that would enable him to assume control in emergencies; he would operate the space scanner and be in general command of the vehicle. A miniature astroviewer, connected in a network with the flight engineer, would permit him to study remote instruments, such as a trip plotter at the engineer's station.

It was assumed that the flight engineer would be responsible for monitoring and maintaining all of the vehicle's vital systems. The vehicle was assumed to have a guided re-entry booster with eight liquid-fueled engines. Separation and booster-return guidance would be controlled from the ground with provision for destruct from the mother ship. The lunar transport was assumed to have five variable-thrust gimballed main engines supplied with a high-energy liquid fuel. Free-flight attitude control would be achieved with three sets of solid-fuel microjets. No provision was made for gravity simulation because of the short duration (1 to 3 days) of the flight; restraints, magnetic shoes, and orientation devices would probably be used. It was assumed that the cabin would be controlled for life support, but that operators would remain in unpressurized spacesuits with provision for automatic pressurization.

An over-all view of the (CONTINUED ON PAGE 56)

Satrac

(CONTINUED FROM PAGE 33)

this would produce oscillation. Therefore the pivots are provided with dampers which remove this oscillation.

A second dynamic problem stems from the fact that centripetal tension does not develop in the couplers until "path transportation." If the hook and ring were not resilient, a small shock would occur at the transition between linear and rotary motion. This is prevented by permitting the hook cable-winch to pay out a short length of cable under controlled tension to absorb the shock.

The vehicles are shown designed for side-by-side docking in the illustrations. Shifting the pivot axes to the ends permits end-to-end docking.

The pinwheeling rates and forces are easily supported. Assuming 15,000-lb vehicles 10 ft in diam, hook and ring extensions of 10 ft each, and relative velocity of 1 fps—Pinwheel rate = 0.64 rpm; Centripetal force = 31 lb = $0.002g$. For most purposes these magnitudes are trivial, so that the tolerance on the approach velocity may be made quite wide, for example, 0.5 to 5 fps.

Orientation of the vehicles along the line of sight has been described, but orientation around the line of sight is also necessary to align the couplers. Such orientation may be accomplished by slaving the axes of both vehicles to the orbit plane and using the local vertical to get the correct sides down.

An alternate and completely self-contained system is to polarize the light radiated by one vehicle and sense the plane of polarization at the other vehicle.

. This technique has a 180-deg ambiguity, which could cause the vehicles to approach on a collision course with booms on the same side instead of the offset course with booms on opposite sides. The ambiguity is eliminated as follows: Initial transverse velocity error rotates the line of sight in inertial space. The direction of this rotation is detected by rate gyros in both vehicles. The target vehicle transmits the direction as a light modulation by selecting the lamp electric power as one frequency for positive rotation and a different frequency for negative rotation. The pursuit vehicle compares this rotation sign with its own corresponding rotation sign. If they disagree, the pursuit vehicle rolls over 180 deg. It may prove advantageous to interchange the polarizer and analyzer and have the target vehicle perform the turnover. This would avoid interference with the pursuit-vehicle thrusting program.

A diagram on page 33 illustrates the relative motion of the two vehicles during terminal rendezvous. Programs for this motion have been developed by others, and are briefly repeated here only for completeness.

Initial conditions for the terminal phase of the rendezvous are assumed to be as follows. The target vehicle is in orbit. The pursuit vehicle has been injected into the orbital path approximately 50 mi. ahead of the target vehicle, going approximately 1000 fps slower than the target vehicle, and oriented with its main engine approximately toward the target. This is the direction of thrust to increase orbital velocity and decrease relative velocity. Velocity relative to the target vehicle has a principal component along the line of sight and two smaller components transverse to the line of sight.

The target vehicle is commanded to orient with its Z_t axis along the line of sight and with its angular rate around the Z_t axis close to zero, under control of a rate gyro shown on the Y_t axis. The pursuit vehicle is also commanded to orient with its Z_p axis along the line of sight.

Sensing Rotation

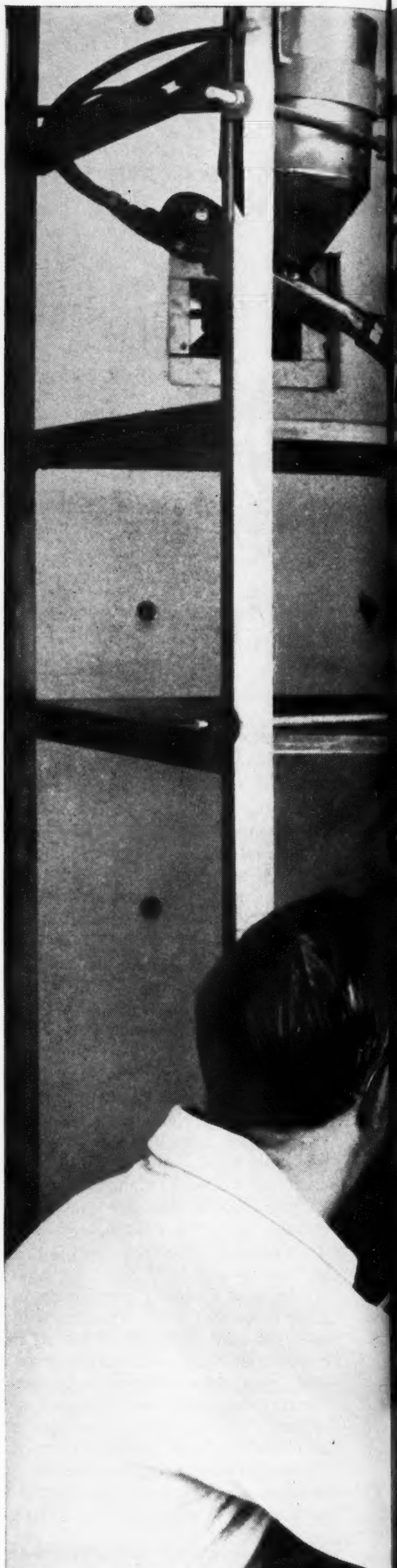
Rotation about Z_p is slaved to the described polarized light so that the X_p and Y_p axes are made parallel to the X_t and Y_t axes, i.e., angle α is driven to zero. Sensing the direction of rotation of the line of sight to eliminate the polarization ambiguity is done by sensing the direction of rate gyros, whose spin axes are parallel to the coupler booms.

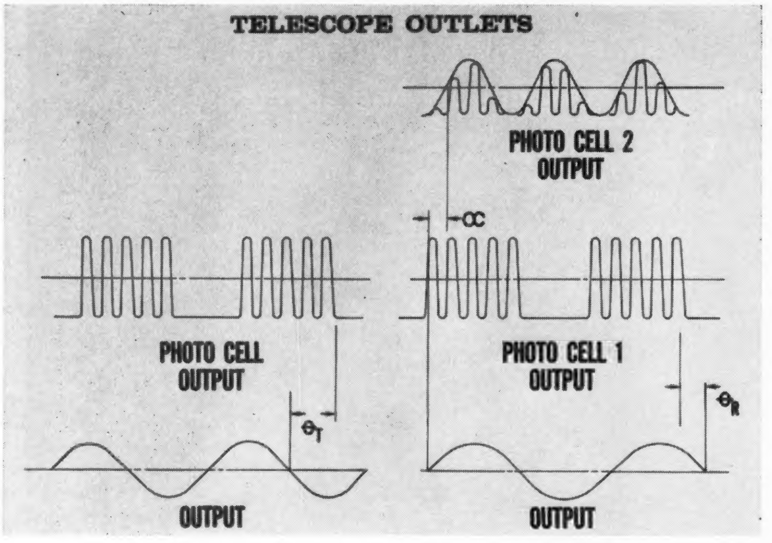
The velocity components V_x, V_y, V_z, now lie along the X_p, Y_p, Z_p axes. The component V_x causes rotation of the line of sight in the XZ plane and, therefore, operates the rate gyro on the X_p axis. The gyro turns on and off the small rockets on the X axis to cancel V_x. Similarly, V_y is measured and cancelled by the rate gyro and rockets on the Y_p axis.

The telescope and rate-gyro assemblies are gimbal-mounted and servo-pointed to the respective target lamps. The vehicle axes are slaved to the telescope axes, but will respond more slowly than the telescope assemblies. The initial search mode is performed with gimbal motion only, with vehicle reorientation only for gross scan if necessary.

No long-range radar is used in the system. In the early portion of the maneuver, range and range-rate are measured as functions of telescope illumination and illumination rate of change. This information is used to limit the main thrust so that the vehicles do not take too long to close.

After the vehicles are within about





1 mi. from each other, no further distance measurement is needed. The closing velocity is established between approximately 0.5 and 5 fps and the vehicles coast together. Attitude and lateral velocity control are maintained until coupling.

Measurement of final closing velocity may be performed by either measuring illumination and illumination rate or by a small, short-range radar.

A drawing on page 33 shows the guidance instruments. The target vehicle carries a lamp and polarizer. The light is sensed in the pursuit vehicle by a direction telescope for line-of-sight determination and a polarization plane telescope for coupler parallelism determination. Similarly, the rendezvous vehicle carries a lamp, without a polarizer, which is sensed in the target vehicle by an error-direction telescope.

Each lamp is a gas-discharge tube operating on alternating current. The light, therefore, is pulsating, and is thus distinguishable from star or earth background. Tuned filters are inserted in the photocell outputs to pass only signals of the lamp frequency. The pursuit vehicle also has a sun sensor which biases its motion to shift the line of sight to exclude the sun from the field of view.

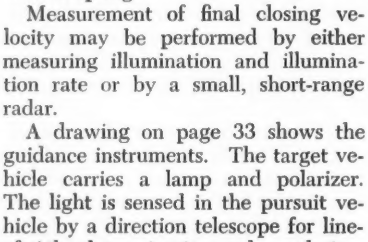
The error-direction telescopes may be made in any of several available forms. The form illustrated uses a photomultiplier tube in front of which is a rotating shutter. The shutter has one transparent and one opaque semicircle. The photoelectric cell output is therefore a current at the lamp frequency, square-wave modulated as shown above here. A resolver coupled to the shutter establishes a reference. The phase angle, θ_T, between the reference voltage and the photocell current envelope is a measure of the position of the vehicle axis relative to the line of sight. Means can be added to measure the magnitude of the deviation in addition to its direction.

The output of the polarization analyzer is also a sinusoidally modulated lamp frequency. The phase angle, α, between the modulation envelope and the resolver reference is the angle between the two vehicles around the line of sight.

Sensitivity of the optical system is much greater than needed. The thermal noise equivalent power of a 1P21 phototube at 1-cps filter bandwidth is 5×10^{-13} lumens. Assuming a 2-in.-diam objective lens, with a 10-deg field of view, a 1000-lumen lamp, a distance of 50 n.mi., and a star background illumination of 22×10^{-9} lumens/cm^2/steradian—the signal-to-thermal-noise ratio is of the order of 16 db. Electron shot noise from starlight background is negligible.

The radar is a small unit, responsive to speed only, with an operating range of about $^1/_2$ mi. It measures the final speed for coupling. It may be possible to eliminate even this radar if proper optical attenuators are switched into the telescope optics to prevent phototube saturation. Since optical measurement of speed is responsive to only the square root of the lamp brightness, and since a final velocity tolerance of 10:1 is permissible, calibration of the system is not critical.

As to the couplers shown in the drawing on page 32, they represent a preliminary design, each comprising a boom extending a cable. The cable on the narrow boom ends in a single hook. The other boom is actually a twin boom. The two ends are joined by a twin "hook receiver," as shown by the drawing below here, the assembly making up the "ring" represented in the sequence at the top of page 32.



In action, the "hook" first engages the end of one of the twin booms, slides along it, and comes to rest in the hook receiver. Both hook and hook receiver have spring latches to prevent accidental uncoupling. Cable tension lifts both the hook and the hook receiver from sockets in their respective boom ends. The booms then retract, and a capstan on the hook-receiver cable draws the two vehicles together, the hook and receiver being drawn over the capstan in the process.

Satrac optical system provides guidance with three-axis relative attitude control and small enough transverse position-error to guide vehicles and their couplers into actual engagement. The Satrac offset couplers provide automatic and shockproof coupling without the need for close control of terminal velocity. Such techniques should make an important contribution to coming space missions. ♦♦

Space Age Astronomy Meeting To Be Held Aug. 7–9 in Calif.

A unique three-day symposium will bring together under one roof leading astronomers and developers of space vehicles and payloads. The symposium on "Space Age Astronomy," sponsored by Douglas Aircraft Co., will be held at California Institute of Technology, Pasadena, Calif., August 7-9, and will enable astronomers and vehicle engineers to exchange ideas and information about space exploration and astronomical observations from spacecraft. E. P. Wheaton, Douglas vice-president, engineering-technical, is chairman of the symposium planning committee, and W. B. Klemperer, Douglas missiles and space systems engineering, program committee chairman.

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Launch Operations Challenge

(CONTINUED FROM PAGE 23)

orbit or from the moon's surface also be applied to launches from the surface of the earth Should we not develop and employ these techniques on our earthbound launch facilities before we even consider an extraterrestrial launch?

The techniques that we presently employ, though costly and time consuming, were of course justifiable in the embryonic stage of our space exploration. These techniques were a part of the growing-up process in our launch-vehicle technology. But we are now *past* this learning stage and are emerging into maturity in launch-vehicle operations. It is time that we develop new and more-refined testing and launch-preparation techniques.

A brief look at a few figures will indicate clearly just how much our present techniques are costing us. The Thor Agena-B, Atlas Agena-B, and Centaur launch vehicles require a field force at the launch site of several hundred men. It takes six to eight weeks—using current procedures—to checkout the thousands of functions of the many vehicle components. The Saturn field force will be even larger, and we estimate that it will take even longer to complete Saturn's checkout prior to flight. Transferred into dollars, the cost of the field force engaged in preparing a vehicle for launch mounts into millions of dollars per flight. Add the field-force expense to the cost of the equipment and facilities at the Cape necessary to support a field crew in conducting its tasks, and the resulting total becomes truly staggering.

As a first step toward combating high launch-preparation costs, NASA recently awarded a contract for construction of an automatic checkout device for Saturn. It is possible that such a system, when perfected, will be able to check out Saturn's first-stage electrical system in a matter of hours far more efficiently and with far less wear and tear on the system than with existing techniques. Such automatic testing should make possible faster launch rates. The effect will be twofold—a greatly reduced operating cost, because of the much smaller field force required, and a substantial reduction in capital cost, because of the fewer number of launch pads required.

However, all of the prelaunch testing techniques in the world are useless if each vehicle part is not constructed with the finest possible craftsmanship—and fabricated and tested by the supplier with full knowledge as to exactly how his product will be used and to what environment it will be subjected. The U.S. space program has been riddled with failures traceable to nickle-and-dime parts that let us down.

In one instance, we traced the loss of a multimillion-dollar launch vehicle and its expensive payload to a loose piece of solder within a small diode. Upon X-ray examination of the supplier's inventory of the diode, it was found that nearly every one contained a loose piece of solder. A further check revealed that these diodes and the one in the doomed launch vehicle were part of a bad run. The supplier had relaxed his quality control and a bad run of diodes resulted. What made the matter even worse was that the supplier had not been informed as to how his diodes were to be used, and therefore proper testing procedures had not been established. Neither were the vehicle checkout procedures adequate to catch this fault.

My point is this. Not only must the vehicle contractor establish adequate checkout procedures, but also each of *his* suppliers must be informed as to the use of their product so that they too can perform adequate tests.

What Is the Solution?

With the problem thus defined, what approach can be taken to abolish the incredibly costly and wasteful techniques presently employed in launch-vehicle checkout? How can we replace these antiquated methods with streamlined, efficient procedures?

The solution cannot be found by merely modifying present techniques or accelerating existing procedures. It will take much stronger medicine than that.

We must adopt an entirely new philosophy of how to design, manufacture, test, and launch our vehicles.

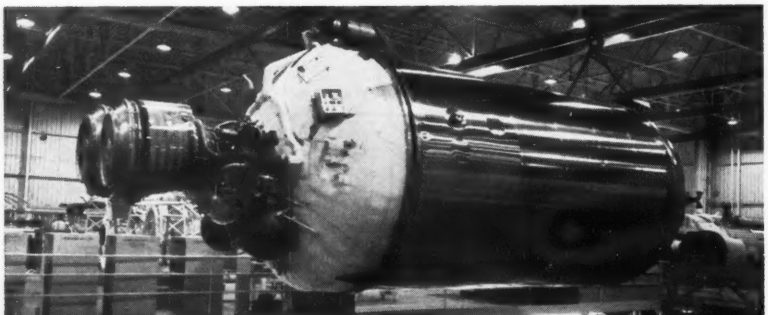
We must first learn to design vehicles with simplicity and reliability in mind. It has been learned through the years that simplicity is the keynote to reliable and economical operation. Then, all aspects of fabrication must be returned to the manufacturing plant. Furthermore, the checkout lines in the hangars at Cape Canaveral must be replaced by in-plant testing and checkout procedures. Each launch vehicle must be complete in every detail—totally checked out and ready for installation on the launch pad—before it is permitted to pass out through the doors of the vehicle contractor's plant.

Finally, new automatic checkout techniques must be developed for use on the launch pad. The many days and weeks of tedious manual checking by the field crews must be replaced with a few hours of checkout using automatic testing equipment.

And what should be the ultimate goal? We should not be satisfied until the residence time of the vehicle at the launch site has been reduced from the present six weeks to no more than six days—nearly an order of magnitude improvement.

This goal is neither fantasy nor wishful thinking. It is *realistic* in terms of our present technology. It is *essential* if we are to afford the space program we want, a winner's program.

♦♦



Centaur On Its Way

The first Centaur second-stage test vehicle moves off the dock at Convair-Astronautics on the way to the company's static-testing facility at Sycamore Canyon near San Diego, Calif. Being developed by Convair for NASA, Centaur employs the Atlas D booster and two Pratt & Whitney LR-115 15,000-lb-thrust lox-hydrogen engines in the second stage. Proper ignition of the twin LR-115's is now under study. The first Centaur flight test is planned for late fall of this year. Centaur will be capable of putting 5000 lb in low orbit, and will deliver lesser loads on deep-space missions.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A
B
C
D
Conventional oil cooling system includes: A. Duct B. Heat exchanger C. Door D. Actuator

Lifting Re-entry Vehicles

(CONTINUED FROM PAGE 31)

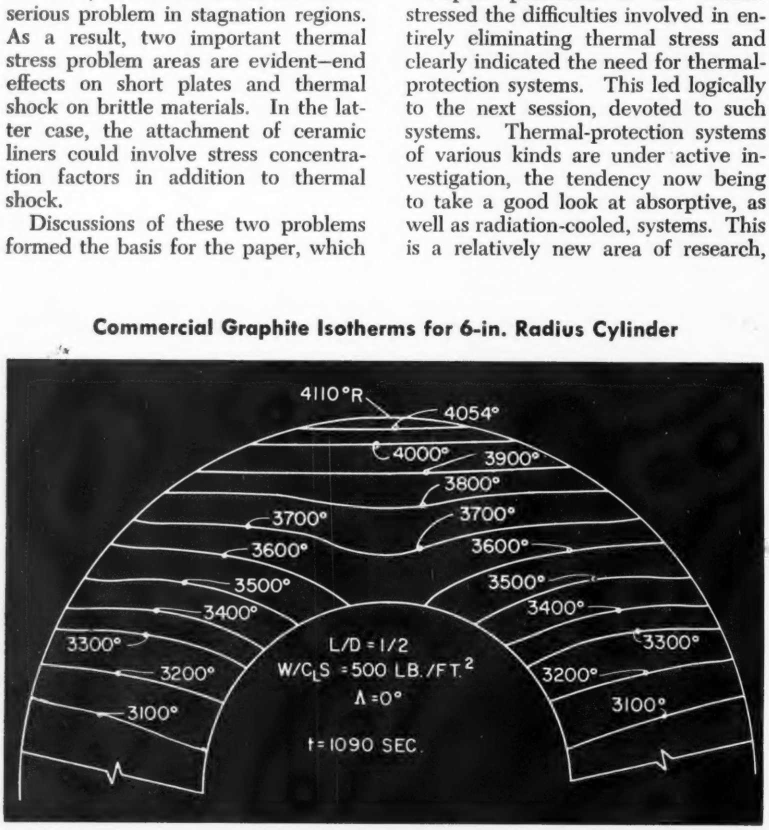
and proper analytical techniques are being developed.

In his paper on "Simplified Thermal Stress Analysis of Re-Entry Structures" (1692–61), Herbert Becker of New York Univ. noted that, from the structural standpoint, re-entry signifies rapidly rising temperatures on nose cones and on low-aspect ratio lifting and control surfaces, and, if ceramics are used, brittleness could become a serious problem in stagnation regions. As a result, two important thermal stress problem areas are evident—end effects on short plates and thermal shock on brittle materials. In the latter case, the attachment of ceramic liners could involve stress concentration factors in addition to thermal shock.

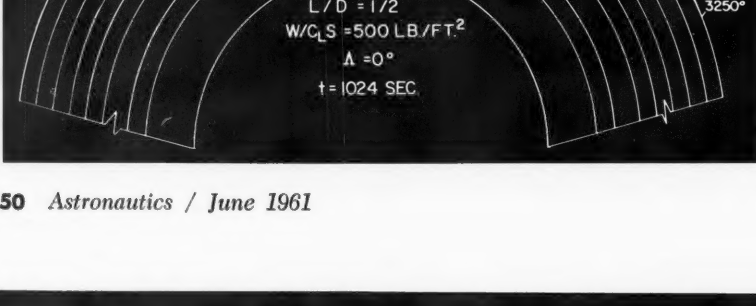
Discussions of these two problems formed the basis for the paper, which aimed at a description of effective methods of attacking the problems to obtain useful data. The author described an analog method for analyzing thermal stresses in plates, and included two applications. In addition, he discussed evidence that mechanical stress concentration factors may be too large for thermal shock fields. These approaches demonstrated broad thermoelastic principles and simplified analytical procedures which could provide useful aids during the process of structural design of re-entry vehicles.

Papers presented at the session stressed the difficulties involved in entirely eliminating thermal stress and clearly indicated the need for thermal-protection systems. This led logically to the next session, devoted to such systems. Thermal-protection systems of various kinds are under active investigation, the tendency now being to take a good look at absorptive, as well as radiation-cooled, systems. This is a relatively new area of research, since until now radiation-cooled systems have been considered desirable for long-time applications, while absorptive systems have been used primarily for short-time applications, such as ballistic missile flights. The crucial problem in using absorptive systems in re-entry vehicles, with much longer flight times, is, of course, the high temperatures encountered, and the development of materials capable of withstanding such temperatures for the long flight times that are involved.

Commercial Graphite Isotherms for 6-in. Radius Cylinder



Pyrolytic Graphite Isotherms for 6-in. Radius Cylinder



Thermal Protection

Highlight of the session devoted to Thermal Protection Systems was the paper by Edward J. Nolan and Sinclaire M. Scala of GE-MSVD on "The Aerothermodynamic Behavior of Pyrolitic Graphite during Sustained Hypersonic Flight" (1696–61). Some 40 hands flew up to indicate questions at the end of Dr. Scala's presentation, and the paper produced a good deal of excited comment during and after the session.

The paper offered a theoretical analysis of the aerothermodynamic feasibility of using pyrolitic graphite as a thermal shield at the nose and leading edges of a hypersonic re-entry glide vehicle. The mechanism of thermal shielding used is re-radiation cooling, since, on employing a refractory material, radiation equilibrium is usually approached shortly after initiation of glide re-entry.

The authors noted that pyrolitic graphite obeys "slow" oxidation kinetics and hence the transition to a diffusion-controlled oxidation can occur at a higher temperature level than "fast" reacting materials. Thus pyrolitic graphite offers the likelihood of flight in the transition regime for a substantial portion of re-entry. In this case, those aerodynamic and geometric factors which produce even a slight decrease in surface temperature act simultaneously to promote a substantial decrease in total mass loss.

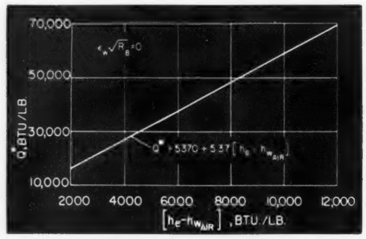
The paper also pointed out that, since the chemical properties (specific reactivity) and anisotropy in thermal and structural properties are directly related to techniques used in manufacturing a particular grade of graphite, systematic experiments will be needed to yield full data simultaneously for a given specimen. When such data are available for several types of pyrolitic materials with tailored properties, systems studies can be carried out to determine tradeoffs between the various thermal, chemical kinetic, and structural properties and to optimize further the over-all behavior of a given system.

While the discussion which followed presentation of the paper indicated

there was some question as to whether pyrolitic graphite would retain its properties (roughly an order of magnitude better than those of currently available materials) after once being exposed to very high temperatures, there appeared to be unanimous belief that the material was well worth additional study.

Another paper of considerable interest at this session was presented by Sidney Allinikov and Fred W. Forbes of WADD, who discussed "A Re-Entry Window or High-Temperature Viewing Device" (1699–61). The paper reported on a thermal-protection system and materials which would enable the vision of the pilot of a re-entry vehicle to be extended to the 2000–2500 F range, and represented a notable advance in systems development in this area.

Effective Heat of Ablation for Graphite in Diffusion Rate Controlled Oxidation Regime



Emphasis on Dynasoar

The meeting culminated logically in the Classified Session devoted to vehicle design, which included a full-scale, up-to-the-minute progress report on Dynasoar—an excellent example of the integration of structures, materials, and design into a full-scale vehicle—by Max T. Braun of Boeing, and a summary of aerodynamic heating data obtained from early Nike-Zeus flights by Ronald J. Tagliani of Douglas.

Discussions at the meeting clearly indicated that a number of very tough problems still exist with regard to lifting re-entry vehicles. First and foremost, of course, is the development of materials in the higher temperature range. Dr. Eggers pointed out in his paper that higher re-entry speeds from super-orbits result in a new regime in which radiation heating becomes even more important than convective heating. Thus a new dimension is added to the whole problem, and new configurations involving new materials, structures, and systems are required.

The meeting produced a number of outstanding contributions in the field of thermal-protection systems, drawing on Materials Advisory Board work, and showed considerable advances in the state of the art. However, it has become obvious that no one system is optimum for all missions, and the requirements of different environments will dictate different configurations and systems.

Also revealed by the conference was the need for further development of ingenious thermal-protection systems which are combinations of new materials and structural configurations. The fact that engineers and scientists are becoming aware of the potentialities of such systems is regarded as encouraging, and it is even more encouraging to see the Air Force going ahead on programs such as Dynasoar. Feasibility of re-entry glide vehicles, as shown by Dynasoar, will unquestionably lead to further programs in this area.

Not to be overlooked at the meeting was the Banquet, which attracted an attendance of 200, nor the twilight poolside reception sponsored by Boeing. Featured speaker at the Banquet was Courtland D. Perkins, Chairman of the Aeronautical Engineering Dept., Princeton Univ., and former AF Under-Secretary. Dr. Perkins' topic was "Management Problems in Military Aero-Space Programming," and his stimulating address was one of the conference high points.

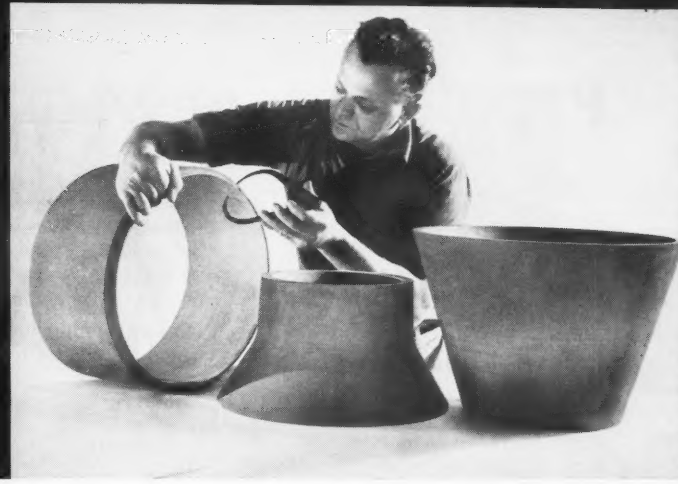
Dr. Perkins pointed out that present military space programs have no real urgency, since it is difficult to define specific military missions for such programs. It was this, he maintained, which was responsible for the dropping of the ANP program and present and past difficulties of the B-70 program.

Another difficulty, he noted, is that there is constant pressure to turn such programs into weapon-system programs, rather than to keep them at the advanced development, or prototype, level. He commented that there are dollar limits in the yearly sums spent for individual programs in each of the four military expenditure categories, as follows: Basic research, $10,000 to $100,000 annually; advanced research, $100,000 to $1 million; advanced development, $1 million to $100 million; and weapon systems, $100 million to infinity. Programs must be made to fit this pattern, he went on, and attempts to force programs which belong in one category into the next highest category frequently make the programs very vulnerable.

Of the military space programs, he added, only Samos has top priority and a clearly defined military mission. Thus, he concluded, the Air Force would only support a project such as Dynasoar in its present, that is, advanced development, form, and efforts to turn what is now a prototype program into a weapon-system program, or to make other basic changes, could cause trouble for the program. ♦♦

Mobile Sergeant System Employs New Steel

In a field demonstration, the nose section of the Army's new Sergeant missile is unloaded from transport trailer and assembled on erector-launcher. The vehicles in this mobile ground-handling and launching system mark the first use of U.S. Steel's newly developed T-1 construction steel alloy, which has roughly three times (100,000 psi) the yield strength of structural carbon steel of the same thickness. Use of the new steel makes a difference of 7000 lb in the erector-launcher alone. Light weight makes air transportation of system practical.



People in the news

APPOINTMENTS

Peter L. Nichols Jr., chairman, ARS Propellants and Combustion technical committee, has been promoted to director of the newly formed Space Sciences and Propulsion Div. at Stanford Research Institute.

Max Lowy, past chairman of ARS' Communications Committee, and presently a member of its Publications Committee, has been named manager of systems integration for Gulton Industries, Inc. **Robert G. Day** has been appointed manager of the company's new Scanner Systems Group and **Donald M. Krauss** will serve as manager of engineering.

Nicholas A. Begovich, assistant manager of Hughes' ground systems group, Fullerton, Calif., and director of product line operations there, has been made a vice-president of the company. **Louis L. Reasor** has been appointed manager of the Tucson, Ariz., division which manufactures Falcon missiles. He will be assisted by **Edward A. Hayes. John W. Black** moves over to corporate headquarters with responsibilities in the field of airborne military systems.

Leonard S. Sheingold has been named Air Force chief scientist for a one-year period. Dr. Sheingold, currently director of the Applied Research Laboratory of Sylvania Electric Products, Inc., will be replaced by **James E. Storer** in the interim. **Harold R. Raemer** becomes a physics specialist at ARL. **Robert R. Goldsborough Jr.** has been appointed manager, Engineering Operations Dept., Reconnaissance Systems Laboratory.

Lt. Col. John R. F. Bond has been named executive officer of Redstone Arsenal, Ala.

Daniel C. Schiavone has been named director of reliability on the corporate engineering staff of Martin Co.

Robert T. Donohue has been appointed to the new post of director, Systems Research Laboratory, Geophysics Corp. of America.

Loren K. Hutchinson has been promoted to manager of operations, Eastern Div. of Wyman-Gordon Co. **Arthur H. Swift** becomes director of plant and equipment engineering for the division.

Gifford K. Johnson has been elected president and chief executive officer of Chance Vought Corp. **J. R. Clark** has been appointed vice-president and general manager of the Astronautics Div., and **D. W. Kraybill** project manager-Saturn. **Charles F. Gell,** chief of Life Sciences for the division, has been appointed chairman of the Life Science Committee of the Aerospace Medical Assn.

Charles F. Lombard has joined Northrop Corp.'s Advanced Research Center, Norair Div. At the Nortronics Div., **Willison K. Vance** has been promoted to director of applications engineering, Systems Support Dept., and **Burl H. Ervin,** to chief engineer for systems support.

Raymond F. Jacque has been appointed manager of quality assurance, Military Products Div., General Dynamics/Electronics.

J. M. Gardiner has been named assistant to the president of Thiokol. **R. E. Davis** succeeds Gardiner as manager of the Washington, D.C., office. **D. R. Thielen** becomes manager of Thiokol's Dayton office.

Norman H. Enenstein, vice-president of Litton Systems, Inc., has been promoted to director of technical administration. **John J. Connolly** succeeds Enenstein as director of the Data Systems Lab at Canoga Park, Calif. **Allen S. Dunbar** has been named manager of space flight activities, Maryland Div. **J. Richard Hechtel** has joined the Research Lab of Litton Industries' Electron Tube Div. as a senior scientist.

Harold A. Cheilek has been named associate technical director of Cornell Aeronautical Laboratory, Inc.

Lloyd M. Adams has been appointed technical director of the new Western Development and Service Div. of Flight Research, Inc., Richmond, Va.

James M. Jans has been upped to chief engineer, Allied Chemical's General Chemical Div. In addition, the following have been named managers of the respective departments: **Robert G. Bierbower,** engineering administration; **John L. Ciba,** design engineering; **Charles W. Gaylord,** process engineering; and **James Jaffe,** process engineering.

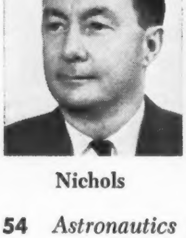
Bernd Ross has rejoined the Semiconductor Div. of Hoffman Electronics Corp. as manager of the solar development section and assistant technical director.

John S. Hall has joined the Kidde Aero-Space Div. of Walter Kidde & Co., Inc., and will serve as manager of manufacturing and procurement.

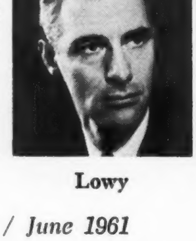
William E. Zisch, vice-president and general manager, Aerojet-General, has been elected executive vice-president. **Howard P. Mason** has been appointed an assistant secretary of the company. **Luke Harvey Poe Jr.** has been named assistant to Dan A. Kimball, president of AG. **John S. Luce** has joined AG Nucleonics, where he will serve as special assistant to H. P. Yockey, head of its Research and Development Div.

M. D. Margolis and **T. H. McNary** have been named program managers for Minuteman production and Research and Development, respectively, Minuteman System Management Div. of Autonetics Div. of North American.

Mark G. Channing has been appointed vice-president in charge of

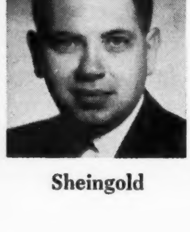


Nichols



Lowy

Begovich



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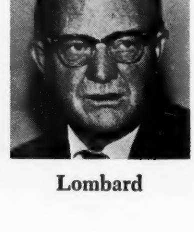


Lombard

Channing

Lewis

planning at Pratt & Whitney, West Hartford, Conn. **Reynold L. Caleen** has been made assistant to the general manager of P&W's Florida Research and Development Center.

Robert E. Lewis has been elected president and chief executive officer and a director of Perkin-Elmer Corp.

Donald G. Fink has been appointed vice-president for research, Philco Corp.

John H. Grover takes over general administrative responsibility of the new "Georgetown Research Project" group of Atlantic Research Corp., while **Hans W. Weigert** will continue to direct the group. **Michael Markels Jr.**, director of the company's Nuclear Engineering Div., will be in charge of the new experimental radiation lab.

R. C. Armstrong will head Convair-Astronautics' new Life Sciences Group.

J. Carl Moore has been appointed director of manufacturing, Aerospace-Rockets Div., Bell Aerosystems Co., and **John P. Leahan**, manager, industrial planning.

HONORS

Capt. Ashton Graybiel (MC, USN), director of research at the Naval School of Aviation Medicine, Pensa-

Graybiel

cola, Fla., and creator of the "slow rotation room" which simulates stress conditions by orbiting vehicles, has been presented the 1961 Eric J. Liljencrantz Award for his studies on the physiological effects of space flight. ♦♦

NASA Spacemobile Brings Astronautics to the Public

The special station wagon shown here will bring astronautics to the public in outlying areas of the country this summer as part of the National Aeronautics and Space Administration's educational programs. Loaded with 20 displays of model space vehicles, such as the Mercury capsule, Ranger, Surveyor, Saturn, Tiros, etc., and various experiments in science related to space flight, it is equipped to bring a graphic picture of our space programs to the layman and student.

Giving lectures and demonstrations will be Donald Cox and John Bartram, his assistant. Dr. Cox has authored several books on space flight for children and adults and has lectured extensively the past four years on our space programs.

Conceived less than a year ago by I. M. Levitt, director of the Franklin Institute Plantetarium in Philadelphia, the "Spacemobile" was set up through NASA's new Office of Technical Information and Education Programs. Under the leadership of Dr. Levitt and James Bernardo, NASA's Educational Services chief, a one-year pilot program with the Spacemobile was launched last winter—officially designated as the NASA-Franklin Institute Traveling Space Demonstration Unit.

The demonstration itself is designed to instruct laymen, teachers, and students in some of the basic principles of space science. Its main program, an hour with demonstrations, answers four basic questions: 1) What is a satellite? 2) How do we get it into orbit? 3) What keeps it in orbit? 4) What good is it?

This summer, Spacemobile demonstrations will be given at various aerospace institutes and workshops being held at the following American colleges and universities: Univ. of Puerto Rico, Mississippi Southern College of Education (Evanston, Ill.), Univ. of Nevada (Reno), Central Washington College (Ellensburg), Long Beach State College, San Fernando State College, and the Univ. of Redlands. Space workshops at Murfreesboro, Johnson City, Tenn., Oxford, Ohio, and Helena, Mont., will also be covered by the unit in the Spacemobile's ambitious first-year program. ♦♦

The NASA Spacemobile shown above will bring demonstrations and lectures on space flight to various communities this summer. Donald Cox, Spacemobile lecturer (below), gives an idea of the many exhibits and models that this traveling classroom presents to an audience.

Lunar Flight Control Display

(CONTINUED FROM PAGE 42)

flight engineer's station, minus power-operated chair, is shown at bottom. Controls to be adjusted during thrust periods would be located on the arms of the engineer's chair. The curved console and three displays grouped in front of the engineer are designed to supply him with all of the information needed to monitor and analyze malfunctions and other unexpected occurrences.

The display-control configuration provides alternate, or malfunction, modes. The man-machine relationship in the proposed system is shown schematically on page 58. Note that the engineer's station is designed to permit the overriding of automated functions in emergencies.

The circular screen directly in front of the engineer's station connects with a miniature-TV-camera network shared with the pilot. By depressing a button on a selector panel beneath the screen, the engineer can read remotely located instruments, visually inspect critical components, assess external damage, and view the space surrounding the ship. This system also contributes to improved visual observation by preventing sudden changes in light level, which could injure the operator's eyes. Automatic video control circuits maintain the screen at a constant and comfortable light level. Camera-lens control provides the operator with either telescopic or wide-angle views.

In military vehicles, the astroviewer could be used to convert radar and infrared data into a visual tactical display for ECM analysis, for reconnaissance, surveillance and camera control with radiation detector inputs, for weapons control, and for navigation, by superimposing reference maps from stored video tapes.

The pictorial system monitor, located to the right of the viewer screen, displays the operational status of 50 major system components with lighted, colored fail-safe panel blocks. Each color block represents an output from the ship's central computer, which continuously compares outputs from hundreds of sensors with stored normal values. If a sensor output deviates from prescribed limits, the corresponding block on the system monitor flashes rapidly and an auditory indication is given. By the time the engineer perceives the indication (approximately 0.2 sec) the computer has selected a redundant or alternate circuit and the signal stops. But if the block on the system monitor does not stop flashing, it is up to the engineer to select another alternate circuit or to institute an emergency procedure.

The present position of the ship and its relation to its planned trajectory and reference grids is displayed by the trip plotter located to the left of the viewer screen. During flight, a ship image moves along a trace representing the programmed trajectory. A flashing red light and audible note indicate a velocity-vector error. Video signals from the ship's scanner, indicating the presence of unexpected bodies or radiation concentrations, are also applied to the trip plotter. If the pilot elects to change course, a new trace appears on the plotter. The flight engineer, therefore, is afforded an instantaneous up-to-date situation display.

The curved control console, beneath the three pictorial displays, contains supplementary indicators in the form of digital meters and status lamps. In addition, a minimum number of control buttons are located on the console within easy reach of the flight engineer.

Control Console Areas

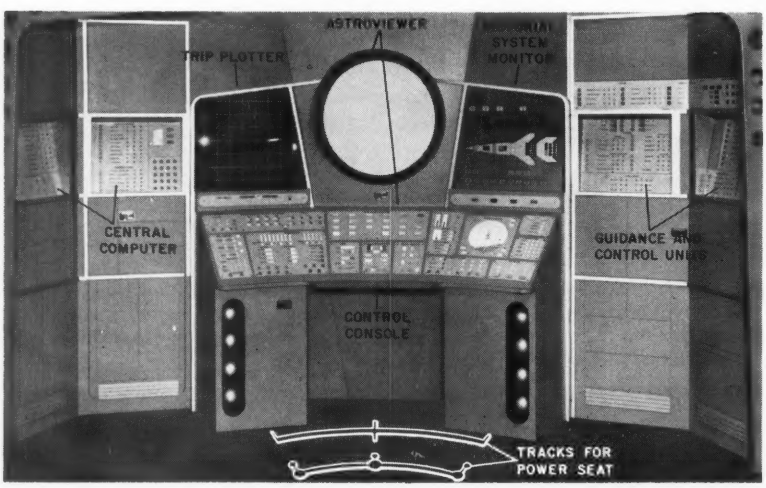
The control console is divided into three main sections. The left-hand section permits the engineer to monitor the environmental-control, life-support, and propulsion systems. The environmental monitor continuously displays internal and external conditions in digital form. The life-support panel indicates the status of the food and liquid storage and the waste-elimination systems. Pressure-outlet lamps for the crew's spacesuits are also supplied as is a check circuit. The propulsion panel indicates the status of the engine, fuel system, oxidizer system, and controller for each of the boosters and main engines. A group of digital meters provides pressure, temperature, and performance readings for each engine as the appropriate selector button-lamp is depressed. If any one of the readings for a particular engine is abnormal, the digits will not change unless a digit-clear button is depressed.

The center section of the console contains astroviewer selectors, a time and communications panel, and redundancy controls.

The time panel displays outputs from the computer. The engineer can obtain present, elapsed, remaining, and arrival time on the digital meter. The communications panel permits control of the ship's various multichannel communications systems. For example, the operating frequency must be changed when switching from earth communication to intership or satellite paths. The redundancy controls contain the digit-clear and manual-override buttons for malfunction modes. The override buttons also serve as status indicators for the computer alternate-mode selector.

The right-hand section of the moni-

Flight Engineer's Station



This model illustrates the nature and possible configuration of display controls for the lunar flight engineer. The circular astroviewer screen permits instantaneous change of pictorial display; the pictorial system monitor to the right of the screen provides an audio-visual status report on over 50 major vehicle systems; the trip plotter to the left presents a radar-like present-position plot with reference to a planned trajectory and external factors. The curved console provides in-flight control buttons and digital displays. A power-operated seat, not shown, would include thrust-period propulsion controls. The layout of the equipment would depend, of course, on the size and shape of a particular space-cabin design.

What's *different* about the NEW 906C VISICORDER OSCILLOGRAPH?

At first glance you may see no difference at all. Just the same functional lines and compact size that you have come to recognize in the Visicorder.

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But the 906C has a new feature you *can* see, (look carefully at the back of the case) and one that represents still another breakthrough; a built-in flash tube timing system which not only generates its own time base, but which can also be triggered *externally*. You can, in other words, use the 906C's timing system to record time lines simultaneously with data. Or you can trigger the timing circuit externally—either by supplying a pulsing voltage of only +10v into 20K ohms impedance, or simply by causing impedance to drop to 100 ohms or less through shorting-out or other means.

Thus your "time" signal may actually be an event marker related to shaft rotation, belt movement, or any other effect which might be more conveniently fed to the timing circuit than to a galvanometer.

(Owners of Visicorders 906, 906A, and 906B will be glad to know that only a *field-change* is necessary to economically and easily add this timing system to their instruments)

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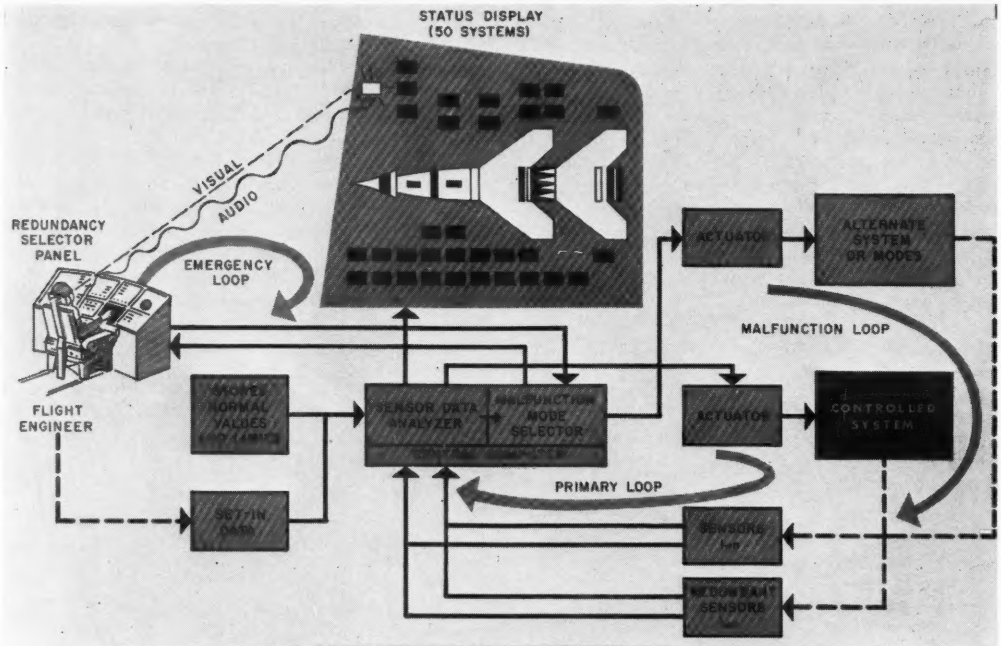
Man-Machine System



The man-machine concept for the proposed display control system is shown diagramatically. Each of the vehicle's vital systems is continuously updated and controlled by a primary servoloop consisting of sensors and redundant sensors, a computer with stored and set-in data, and a system actuator. The computer continuously compares sensor values with stored values and supplies appropriate commands to the system through the actuator. In event of malfunction, the computer selects an alternate mode or an alternate system. If the alternate-system selection does not occur, or in an emergency, the flight engineer can override the computer.

tor console is devoted mainly to guidance and control monitoring. Indicators show in-flight velocity and attitude and, when applicable, radar altitude. Injection into planned trajectory, in this case, is controlled from groundbased equipment; but digital meters indicate errors in path angle, cutoff altitude, and injection velocity.

An attitude-control panel indicates the status of the ship's dual pitch-, yaw-, and roll-control rockets. The flight engineer can check the pressure, valve position, and energy remaining for each microjet by depressing the appropriate test button. Monitors for reaction wheels or spin stabilization would be included here.

Except for electrical power selection and monitoring, the remaining indicators are devoted to monitoring the terminal phase of the flight. If, during landing, the ship should begin descending too fast or its attitude should vary beyond prescribed limits, the pilot must assume control. Digital meters indicate descent rate, height above pad, and horizontal and vertical deviation from the programmed approach line.

There is a central digital computer on the left wall and guidance and control units on the right wall of the flight engineer's station. The indicators and controls on the computer and guidance units are intended for use during prelaunch or routing in-flight checks only, and are not required for monitoring system performance. The computer comprises four sections—guidance and control, environment, propulsion, and programming and storage.

Guidance Functions

The guidance section performs all of the operations required to determine the present position of the ship, compare it to the planned course, and, based on new inputs, compute a new course. The control channel of the computer receives sensor signals representing the ship's attitude and issues commands to orient the ship according to orders from values set in at the pilot's station. During initial and terminal phases of the ship's flight, the computer processes commands from groundbased equipment.

The computer also receives environmental data, such as temperature, pressure, humidity, O_2-CO_2 ratio, and radiation level, and compares them to stored human limits. If the results are abnormal, order signals are issued to correct the condition.

In response to signals from the pilot, the engineer, or the guidance section of the computer, the propulsion section of the computer controls the position, burning, and thrust of the ship's booster and main engines. In addition, this section calculates expended and remaining fuel.

The fourth section of the computer handles memory storage and selection, timing, programming, and automatic self-checking and alternate-mode selection. In addition to this self-checking by the computer, the engineer can check each loop during preflight or nonthrust periods by depressing a test button. Successive depressions of the test button sequences the loop through each of its three possible modes.

The guidance and control units are located on the right side of the engineer's station. The major divisions of the system are guidance, stabilization and control, and space surveillance.

During initial and terminal phases,

primary guidance commands are telemetered from a ground base, and the shipboard guidance equipment functions only as a check on the received guidance commands. During the midcourse phase of a flight, however, the shipboard guidance system is continuously active. Basically, the system consists of a stabilized planet-and-sun tracker which supplies angles between two planets and the sun reference to the guidance section of the computer where, with a precise time reference and planet-position information from storage, the exact present position of the ship is computed. The stabilization and control circuits monitor and control the pitch, yaw, and roll attitude of the ship with respect to a reference generated by the planet-sun tracker. Attitude corrections are generated continuously. The space surveillance system, or space scanner, consists of beacon receivers, a scan radar with moving-target indication, and an infrared omnidirectional scanner. As with the computer, the guidance system can be checked-out by the flight engineer using panel-mounted test buttons.

The actual physical design of these instruments, panels, and consoles would be dependent on the room size and shape in a particular space vehicle. But the model illustrates the type and extent of instrumentation required for major space missions.

Suggested Additional Reading

Josephs, Jess J., "A Review of Panel Type Display Devices," *IRE Proceedings,* August 1960, p. 1380.

Woodson, W. E., Human Engineering Guide for Electronic Equipment," Univ. of Calif. Press, Berkeley, 1957.

Staff Report of the Select Committee on Astronautics and Space Exploration, Space Handbook, U.S. Government Printing Office, 1959.

Mayo, A. M., Space Cabin Design, El Segundo Div., Douglas Aircraft Co., El Segundo, Calif.

♦♦

UCLA Offers Short Courses in Space Technology during July

The Engineering Extension and Physical Sciences Extension department of the University of California will conduct short courses for credit in Advances in Space Propulsion, July 3–14, and in Space Power Systems, July 17–28. Donald J. Simken, head of the Propellant Chemistry Dept., Astropower, Inc., and George C. Szego, senior member of STL's technical staff, are the instructors for the first course; Dr. Szego will also give the second course. Guest lecturers have been enlisted for the program.

Further information concerning the program may be obtained by writing Engineering Extension, Room 6266, Engineering Building II, Univ. of California, Los Angeles 24, Calif.

ARS news

National IAS-ARS Joint Meeting Brings Outstanding Luncheon Speakers and Technical Program

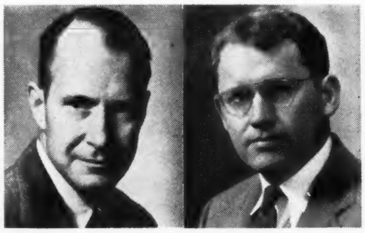
An outstanding technical program will be complemented with luncheon talks by four leading figures in today's aerospace field at the National IAS-ARS Joint Meeting to be held June 13–16 at the Ambassador Hotel in Los Angeles, Calif.

The luncheon speakers on the first day of the conference will be H. Guyford Stever, president of the IAS and professor of aeronautics and astronautics at MIT, and Harold Ritchey, president of the ARS and vice-president of Rocket Operations, Thiokol Chemical Corp.

Wednesday's speaker will be Walter Williams, NASA's assistant director for operations, Space Task Group. Trevor Gardner, chairman of the board of Hycon Mfg. Co., will speak on Thursday, June 15.

The meeting marks the first time that the two largest societies concerned with aeronautics and space technology have held a major joint meeting. The occasion will combine the traditional ARS Semi-Annual Meeting and the IAS Summer Meeting.

Top experts in all the aerospace fields will present more than 110 technical papers during the 32-session program. The subjects will cover a broad range of technology



Ritchey Stever

from VTOL aircraft to deep-space vehicles. The program will provide quadruple concurrent sessions in the morning, afternoon, and evening.

On Friday, June 15, the final day of the meeting, a field trip to the Naval Ordnance Test Station (Pasadena) has been planned by the ARS Underwater Propulsion Committee.

Headquarters for XIIth International Astronautical Congress Named

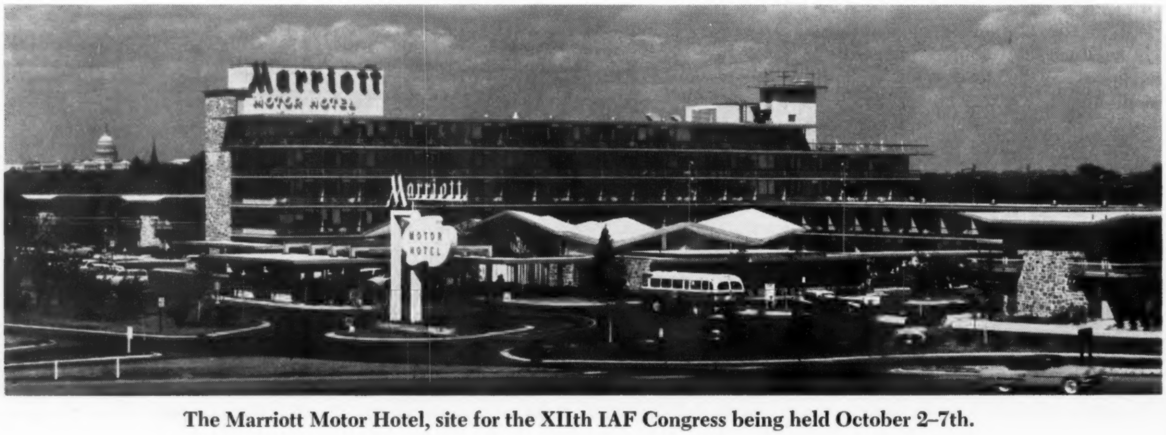
The Marriott Twin Bridges Motor Hotel in Washington, D.C., will be headquarters for the XIIth International Astronautical Congress to be held October 2–7, it has been announced by Samuel Herrick, chairman of the XIIth Congress.

The modern and spacious hotel, located close to the Washington National Airport, will be the scene of technical sessions, IAF plenary sessions, the meeting of the Academy of Astronautics, and the Institute of Space Law.

The banquet date has been changed to Thursday, October 5. The banquet will be held at the Marriott Twin Bridges Hotel. Sites for the opening ceremony and the two receptions will be announced at a later date.

The American Rocket Society is acting as host organization for this year's IAF Congress. The program for the Congress will contain two types of sessions—the standard technical session, with formal papers, and roundtable discussions.

The International Astronautical Federation is composed of 37 professional societies from 30 nations who have united to promote and stimulate the achievement of space flight as a peaceful project. The annual Congresses have been held to disseminate internationally technical and other information on the space sciences.



The Marriott Motor Hotel, site for the XIIth IAF Congress being held October 2–7th.

IAA Space Flight Symposium Will Be Held This Month

The International Academy of Astronautics of the IAF has announced the provisional program of its international symposium on "Space Flight and Re-entry Trajectories" to be held June 19–21 at Louveciennes, Paris.

The organizing committee is comprised of Paul A. Libby, Brooklyn Polytech; Luigi Broglio, Univ, of Rome; D. G. King-Hele, Royal Aircraft Establishment; J. M. J. Kooy, Univ. of Breda; Jean Kovalevsky, Observatoire de Paris; Rudolf Pesek, Academy of Sciences, Czechoslovakia; and B. Fraeijs Veubeke, Université de Liege. Theodore von Karman and Paul A. Libby will officiate at the opening ceremony on June 19.

Sessions scheduled are as follows. Monday, June 19, 2:30 p.m., "Trajectories for Lunar and Interplanetary Missions"; Tuesday, June 20, 10:00 a.m., "Orbital Transfer and Rendezvous" and 2:30 p.m., "Near Earth Satellites"; and Wednesday, June 21, 10:00 a.m. and 2:30 p.m., "Dynamics of Terminal Re-entry."

For additional information, please write: Secretariat, Intl. Academy of Astronautics, 12 rue de Gramont, Paris 2°, or cable: Acadastr Paris.

TECHNICAL COMMITTEES

Deep-space communications, scientific instrumentation for space studies, communication satellites, data-from-space analysis, robots for space exploration, nuclear-propulsion instrumentation, and other subjects will be organized by the **ARS Communications and Instrumentation Committee** for presentation in sessions at the SPACE FLIGHT REPORT TO THE NATION, which will be held October 9–15 in New York's Coliseum. The Committee is soliciting papers now. The Committee, notes chairman Frank Lehan of Space Electronics Corp., does not plan any specialist conference within the next 15 months.

SECTION NEWS

Central Indiana: The Section began its 1961 schedule with a dinner meeting, attended by 75 members and guests, in late March. Guest speaker was **W. C. Fagan,** chief of the Booster and Power Branch of the Dynasoar System Project Office at WADD, who discussed the Dynasoar program. His presentation concluded with a color movie of a Titan launching.

—**John P. Schmitt**

Chicago: The March meeting, held at the Army Officers Club, heard **John A. Hrenack** of the Missile Engi-

On the calendar

1961

June 13–16	**National IAS-ARS Joint Meeting, Ambassador Hotel, Los Angeles.**
June 14–16	ASME Applied Mechanics Conference, Illinois Institute of Technology, Chicago.
June 19–21	Heat Transfer and Fluid Mechanics Institute Conference, Univ. of Southern California, Los Angeles.
June 19–21	**International Academy of Astronautics Symposium on Space Flight and Re-entry Trajectories, Paris.**
June 19–23	Fifth Biennial Conference on Carbon, Pennsylvania State Univ., University Park, Pa.
June 23–24	Franco-Italian Colloquium on Sounding Rockets, Paris
June 26–28	First European Symposium on Space Technology, London.
June 26–28	IRE Fifth National Convention on Military Electronics, Shoreham Hotel, Washington, D.C.
June 26–28	AIEE Aeorspace Electricity Conference, Benjamin Franklin Hotel, Philadelphia, Pa.
June 26–30	"Concepts and Design in Aero-Space Electricity" is theme of 1961 Aero-Space Transportation Committee (AIEE), Benjamin Franklin Hotel, Phladelphia, Pa.
July 5–8	AEC First International Univ. of California Materials Conference, Univ. of California, Berkeley.
July 9–14	4th International Conference on Bio-Medical Electronics and 14th Conference on Electronic Techniques in Medicine and Biology, Waldorf-Astoria Hotel, New York, N.Y.
Aug. 1–3	4th Western Regional Meeting of American Astronautical Society, Sheraton-Palace Hotel, San Francisco, Calif.
Aug. 7–9	**ARS Guidance and Control Conference, Stanford Univ., Palo Alto, Calif.**
Aug. 14–22	Modern Developments in Heat Transfer special summer course, Univ. of Minnesota, Duluth, Minn.
Aug. 15–17	1961 Cryogenic Engineering Conference, Univ. of Michigan, Ann Arbor, Mich.
Aug. 16–18	**ARS International Hypersonics Conference, MIT, Cambridge, Mass.**
Aug. 23–25	**ARS Biennial Gas Dynamics Symposium, Northwestern Univ., Evanston, Ill.**
Aug. 28–Sept. 1	International Symposium on Rockets and Astronautics sponsored by Japanese Rocket Society, Tokyo.
Aug. 28–Sept. 1	International Heat Transfer Conference, Univ. of Colorado, Boulder, Colo.
Sept. 6–8	IRE National Symposium on Space Electronics and Telemetry, Albuquerque, N.M.
Oct. 2–4	Seventh National Communications Symposium of IRE Professional Group on Communications Systems, Municipal Auditorium and Hotel Utica, Utica, N.Y.
Oct. 2–7	**XIIth International Astronautical Congress, Washington, D.C.**
Oct. 4–6	American Society of Photogrammetry Semi-Annual Convention, Biltmore Hotel, New York, N.Y.
Oct. 9–15	**ARS SPACE FLIGHT REPORT TO THE NATION, New York Coliseum, New York, N.Y.**

1962

Jan. 24–26	ASME Thermophysical Properties Symposium, Princeton Univ., Princeton, N.J.

ARS Maryland Section Sees NASA-Goddard SFC Operations

One-hundred and fifty members and guests of the Maryland Section recently toured NASA's new Goddard Space Flight Center in Beltsville, Md., and heard of its many activities from Harry Goett, Goddard director, John Disher, head of advanced manned systems, and others of its staff. Above left, H. C. Filbert (center), Maryland Section president, thanks Dr. Goett on behalf of the Section for the courtesies extended to the visiting group, as Dr. Disher looks on. Above right, the group gets briefed on Goddard tracking operations.

neering Dept. of McDonnell Aircraft discuss "Performance of Hypervelocity Flight Vehicles." The skip-type re-entry vehicle, Hrenack pointed out, experiences something less than 10 g deceleration for a manned-modulated entry, compared with about 70 g for a ballistic missile. Optimally, one would like to maneuver this vehicle at maximum velocity, or with minimum deceleration, and this necessitates a dual guidance system, such as reaction jets for space and control surfaces in atmosphere. Although under extensive study, this kind of vehicle, he noted, is not presently being considered as a weapon.

Discussing the ballistic vehicle, Hrenack observed that its heating is similar to that of the skip vehicle, and that a heat sink was first used to alleviate this problem, with the shift now to ablating materials, and some work being done on transpiration (sweat) cooling.

He also reviewed the boost-glide, dynamic-soaring vehicle, such as the Dynasoar, which flies entirely within the atmosphere. It transforms its kinetic energy into range and possesses an evasive maneuver not found in the ballistic missile, since it has terminal guidance, or a target matcher. Finally, Hrenack reviewed satellite dynamics.

The Section exhibited its Edroc classroom-demonstration rocket engine at the National Science Teachers Association meeting March 24 in conjunction with the Noble and Noble Publishers' display. Also, members of the Lane Amateur Rocket Club displayed photos of their rocket launching at Fort Bliss and explained the Edroc program.

—R. Warder

Columbus: Members and guests met in April at Battelle Memorial Institute to hear **Alan Gray** of GE's Flight Propulsion Laboratory, Evendale, Ohio, discuss nuclear power generation and its application to spacecraft propulsion devices, including nuclear reactors, shielding problems, the turbogenerator, the ion machine, and the plasmajet. Theoretical and economic aspects were considered. Following the program a movie, "Tall Man Five Five," depicting the mission of the B-58, was shown.

—James A. Laughrey

Maryland: Our meeting at the NASA Goddard Space Flight Center in March was a very successful affair, and the people at Goddard did an outstanding job for us. About 20 of the technical staff served as guides for a very complete tour of the facilities. This was followed by an address by **Harry Goett,** Goddard director, who discussed the mission of the Center and plans for its future. Following Dr. Goett, **John Disher,** head of advanced manned systems, discussed Project Mercury, the fourth topic in our "Man in Space" program for the year. We had approximately 150 in attendance for the affair.

—H. C. Filbert

1961 ARS Meeting Schedule

Date	Meeting	Location	Abstract Deadline
June 13–16	National IAS-ARS Joint Meeting	Los Angeles, Calif.	Past
Aug. 7–9	Guidance and Control Conference	Palo Alto, Calif.	Past
Aug. 16–18	International Hypersonics Conference	Cambridge, Mass.	Past
Aug. 23–25	Biennial Gas Dynamics Symposium	Evanston, Ill.	Past
Oct. 2–7	XIIth International Astronautical Congress	Washington, D.C.	Past
Oct 9–15	ARS SPACE FLIGHT REPORT TO THE NATION	New York, N.Y.	Past

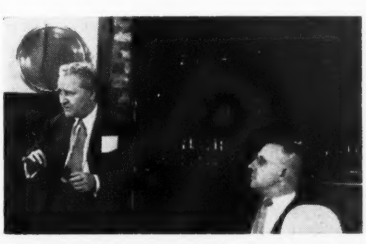
New England: The Section held its second meeting of 1961 in April at the Information Technology Laboratories, a division of Itek Corp. The evening's featured speaker, **Duncan E. MacDonald,** vice-president of the Information Technology Laboratories, gave a talk entitled "The Blind That Ties," concerning photo reconnaissance as a tool for the Free World. Some 60 members and 20 guests attended.

—L. R. Michel

Northern California: Those attending the regular March meeting were treated to a learned discussion of "Electromagnetic Conductivity of the Upper Atmosphere" by **Donald C. Lorents** of the Chemical Physics Dept., Stanford Research Institute. Dr. Lorents described work sponsored by the Army Signal Corps regarding propagation of electromagnetic signals under defined atmospheric conditions. The traditional equations used to define wave propagation were found to be inadequate; and new, more-specific equations were developed which amplified the analysis and confirmed general applicability of the traditional equations.

Prof. E. Sanger, director of the Jet Propulsion Institute, Stuttgart, Germany, attended the meeting. Prof. Sanger, as president of the German Rocket Society, brought salutations to the ARS and spoke briefly of current activity. A European Space Club has recently been formed by European nations, and patterned after the Cooperative Nuclear Research Organization, except that non-NATO countries, such as Switzerland and Austria, are also included.

Activities of the German Jet Propulsion Institute have been directed toward fundamental problems associated with propulsion. A steam-rocket project has shown considerable promise for limited applications, wherein they have achieved a specific impulse of 50 sec at a cost of 25 to 30 cents per ton-second. Nuclear-beam systems are being studied to determine the forms in which the energy exists in



Professor Sanger speaking at the ARS Northern California Section meeting. At the right, Howard Kindsvater, Section president.

the beam. Two specific investigations concern the possibility that high rotational energy of particles produce higher temperatures than anticipated within the exhaust gases and resulting ionization and phenomena associated with the radiation behavior. Investigation of the effect of molecular impact on super-smooth surfaces has produced speculation regarding ability to affect significantly aerodynamic boundary layer effects in supersonic flight by use of supersmooth surfaces.

—**R. O. Webster**

St. Louis: In February, Maj. Gen. **Don R. Ostrander,** NASA director of launch-vehicle programs, was the featured speaker at the joint NASA, IAS, IRE, SAE, and ARS Engineer's Club of St. Louis meeting, discussing "The Present and Future Status of Launch Vehicle Systems," and outlining NASA's projects Mercury, Ranger, Surveyor, Prospector, and Apollo for an audience of some 80 members and guests. A dinner held prior to the meeting for Gen. Ostrander was attended by officers of the professional societies and leaders of St. Louis space industries.

—**Lee F. Carter**

Study Continued on New ARS Headquarters

The Board of Directors has accepted the recommendation of ARS Development Committee Chairman James R. Dempsey that no action be undertaken at present on a future headquarters building for the Society. The Committee will continue its study of the economics of headquarters operations, future floor space needs of the office staff and expected functions of the staff, and the consideration of appropriate geographical locations for headquarters, Mr. Dempsey informed the Board in a report to the April 12 Board meeting. *Astronautics* will continue to keep members informed on these studies.

Tennessee: Data-handling problems and techniques were discussed at the March meeting by guest speaker **C. J. Hesner,** manager of Space Systems, IBM Systems Center. In particular, he covered problems and techniques involved in the flow, processing, and control of data which emanates from satellite-mounted sensors and extends through to a display on the ground. Midas and Mercury were used to illustrate his presentation.

The Section is sponsoring a series of lectures for junior high school students, aimed at presenting a picture of how to select and prepare for a vocation. The participating speakers and their topics are: Reverend Bob Matthews, "How Do I Select a Vocation?"; R. L. Young, "Preparing for a Vocation"; Bruce Galbraith, "Medical Careers"; Jack Durand "Careers in Science and Engineering"; and Pete Trenchi, "Careers in Law and Government."

—**T. J. Gillard**

STUDENT CHAPTER

Univ. of Michigan: The Chapter had as speaker for its March meeting **Wilfred Kaplan,** professor of mathematics and lecturer in astronomy at the University. His talk was entitled "A Survey of Celestial Mechanics."

Elections were held at this meeting. Taking office next fall will be Jesse Brown Jr. as chairman, Richard T. Wetherald as vice-chairman, Peter T. Kirschner as treasurer, Richard A. Auhll as recording secretary, and Judith M. Forde as corresponding secretary.

—**Judith M. Forde**

CORPORATE MEMBERS

Aerojet-General recently dedicated its $\$1^1/_4$-million Astrionics Building at Azusa, built for production of the Midas infrared subsystem . . . **Atlantic Research** has formed a group known as the "Georgetown Research Project" to work in military intelligence and social science research. The GRP was formerly associated with the Graduate School of Georgetown Univ. AR's new experimental radiation laboratory in the Washington, D.C., area, opened shop last month . . . **Boeing** is having a high-altitude chamber with explosive decompression features built for them by the Vacudyne Corp. of Chicago.

A facility for simulating outer space conditions, in which semiconductor materials will be studied, is being built by **CBS Laboratories** at its Research Center in Stamford, Conn. . . . Convair-Astronautics Div. of

General Dynamics has organized a new Life Sciences Group. The division is building a controlled underwater explosion facility for forming Atlas and Centaur parts . . . **General Motors'** Delco Radio Div. plans to have its new semiconductor manufacturing facility ready for May 1962 occupancy . . . **Geophysics Corp. of America** has acquired Vacuum Specialties, Inc., Somerville, Mass. . . . **IBM's** new Thomas J. Watson Research Center in Yorktown, N.Y., for the study of computer science will house some 1500 scientists and personnel . . . **Linde Co.** has announced it will build a liquid helium plant at Amarillo, Tex.

Martin-Baltimore has established a new Nuclear Chemistry Dept. in a move to integrate nuclear chemistry activities there and at Quehanna, Pa. Martin has been selected by the National Bureau of Standards as one of a number of companies to calibrate "unsaturated standard cells" used in measuring accurately the voltage in an electrical system . . . **Northrop Corp.** is installing a General Dynamics Triga Mark-F "pulsing" reactor at its Norair Div. . . . **The Ralph M. Parsons Co.** recently received a Certificate of Appreciation "for outstanding service it had rendered the U.S. Army while performing architect-engineering design work for highly technical facilities for AMBA and ARGMA . . . **Philco** formally opened its new 45,000-sq-ft building in Fort Washington Industrial Park, Pa., for its expanding Communications Systems Div.

Republic unveiled its $14 million three-level Research and Development Center dedicated in memory of Paul Moore, one of the founders of the company, at Farmingdale, N.Y. . . . The Onan Div. of **Studebaker-Packard** has opened a new Technical Center.

Raybestos-Manhattan, Inc. Becomes Corporate Member

Raybestos-Manhattan, Inc., Manheim, Pa., has become a corporate member of the AMERICAN ROCKET SOCIETY and will participate in Society activities. The company manufactures asbestos felts, mats and molding compounds used in the manufacture of rocket and missile components, asbestos reinforced molded shapes, and fluorocarbon basic shapes and finished parts.

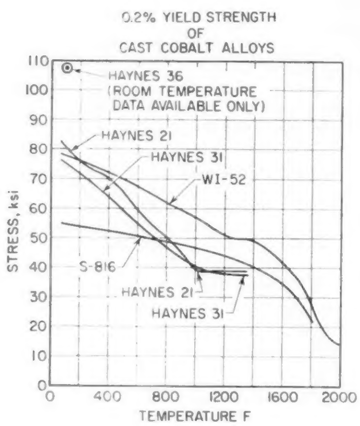
Named to represent the company are R. L. Moore, director of research; M. M. Gibson, product manager; C. P. Ellis Jr., Western district manager; R. F. McMurtrie Jr., sales engineer, San Francisco District, Reinforced Plastics Dept.; and H. G. Platt, sales engineer, Philadelphia District, Reinforced Plastics Dept. ◆◆

ASTRONAUTICS Data Sheet — *Materials*

Compiled by C. P. King, *Materials and Process Section, The Marquardt Corp., Van Nuys, Calif.*

CAST COBALT ALLOYS

The difficulties encountered in working and machining high-temperature alloys have led to a great increase in the popularity of the casting method for jet-engine, rocket, and missile parts. Among such alloys, those based on cobalt have found applications for their resistance to oxidation and corrosion and excellent strength at high temperatures. Although sand and shell casting have been used to a limited extent for some of the cobalt alloys, the investment-casting method has found the greatest application.



Melting and Casting

Induction and indirect arc are the most common melting methods for the cobalt alloys. Air melting and air casting are applicable to all the alloys included here, because, unlike the nickel-base alloys, the cobalt alloys do not employ readily oxidizable aluminum and titanium for precipitation-hardening effects. However, argon and vacuum melting and casting are also used, and generally improve ductility and long-time properties.

Heat Treatment

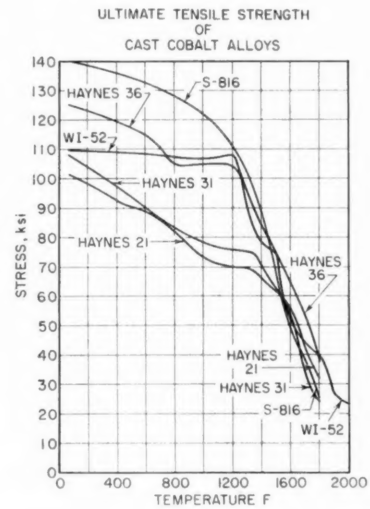
These alloys are usually used in the as-cast condition. However, age hardening occurs at temperatures above 1200 F and results in an increase in strength at the expense of ductility.

Welding and Brazing

Inert-gas-shielded arc welding is preferable for these alloys, and preheating should be used. Brazing is employed to a limited extent.

Applications

The jet-engine industry is one of the largest users of the cast cobalt alloys. Investment casting, particularly, is being used to produce turbine blades, vanes, and nozzles.



Physical Properties of Cast Cobalt Alloys

Alloy	Density lb/cu in.	Coefficient of Thermal Expansion micro-inches/in./F					Thermal Conductivity BTU in./sq ft/hr/F				
Temp F		70–600	70–800	70–1000	70–1200	70–1500	392	572	752	932	1112
Haynes Stellite No. 21	0.299	7.83	7.96	8.18	8.38	8.68	101	111	121	132	142
Haynes Stellite No. 31	0.311	7.84	8.08	8.39	8.75	9.19	103	121	127	135	152
Haynes Stellite No. 36	0.326	7.6	7.8	8.0	8.3	8.9	90	104	116	129	143
S-816	0.313	7.65	7.92	8.06	8.45	8.87	106	117	133	144	161
WI-52	0.321	7.6	7.8	8.0	8.3	8.8	174	179	181	189	191

Chemical Composition (%) of Cast Cobalt Alloys

Alloy	C	Cr	Ni	Mo	Fe	Si	Cb + La	Mn	B	W
Haynes 21	0.20–0.35	25.00–30.00	1.50–3.50	4.50–6.50	2.0 max	1.0 max	—	1.0 max	0.007 max	—
Haynes 31	0.45–0.55	24.5–26.5	9.5–11.5	—	2.0 max	—	—	—	—	7.0–8.0
Haynes 36	0.35–0.45	17.5–19.5	9.0–11.0	—	2.0 max	0.35–0.65	—	1.0–1.5	0.01–0.05	14.0–15.0
S-816	0.32–0.42	19.0–21.0	19.0–21.0	3.50–4.50	5.0 max	1.0 max	3.5–4.5	1.0–2.0	—	3.50–4.50
WI-52	0.40–0.50	20.0–22.0	1.0 max	—	1.0–2.5	0.5 max	1.5–2.5	0.5 max	—	10.0–12.0

Stress-Rupture Properties of Cast Cobalt Alloys

Alloy	Stress to Rupture, in 10 Hours, psi			Stress to Rupture, in 100 Hours, psi					Stress to Rupture, in 1000 Hours, psi		
Temp F	1200	1500	1800	1200	1500	1600	1700	1800	1600	1700	1800
Haynes No. 21	70,000	27,500	12,500	52,000	19,000	18,000	14,000	9,400	13,400	10,000	7,000
Haynes No. 31	61,000	33,000	13,000	56,000	27,000	21,000	17,000	11,300	16,500	14,500	9,800
Haynes No. 36	—	36,000	15,500	72,000	24,000	16,000	11,000	10,000	18,500	12,300	7,300
S-816	83,000	37,000	8,800	65,000	29,000	16,000	13,000	5,500	9,000	—	3,100
WI-52	—	—	16,200	—	—	24,000	19,000	12,800	22,000	15,000	11,000

CUT ALONG THIS LINE

Careers in astronautics

By Irving Michelson, *Illinois Institute of Technology*

Some months ago, when we first pointed out the association of core drill engineers with upcoming space programs, we commented: What strange bedfellows the Spage Age doth make! In the meantime, NASA has announced three lunar exploration programs which entail a high state of development of lunar surface sampling techniques, culminating in the return to earth of samples taken as much as 5 ft below the moon's surface. Thus the space-vehicle designer now has his drill problem more clearly defined. In addition, such programs have intensified the efforts of a wide assortment of space-science specialists, both in areas already clearly recognized, and in a number of new fields.

Not the least important of these fields is that of solar energy. Solar cells have certain obvious advantages when we are dealing with a vehicle which requires the most precise kind of attitude control both in flight and during orbit maneuvers, which makes a soft landing on the moon and carries out other operations on the lunar surface, and which is then launched on a journey back to earth by a remote command signal. Of course, solar energy is important enough to assure a strong development effort even without a lunar exploration program, but the present moon-study projects are of such great interest that they will undoubtedly spur work in this field even more.

A measure of the importance of solar-cell development is indicated by the fact that the first firings of Ranger (the first of the three NASA lunar programs) will be devoted largely to testing in this area. In addition, the early Rangers will seek data on temperature control, since this is an acute problem in vehicles which execute programs of the lunar-exploration type. Thus we can see that solar-energy specialists, heat-transfer experts and designers will be much in demand in the months that lie ahead.

The first two Ranger firings are destined for highly elliptical earth orbits, rather than lunar landings, which opens the possibility for additional studies, since no moon package will be carried. These vehicles are intended to explore purely scientific questions, such as hydrogen and dust counts in deep space, as well as measurement of fields and charged particles. Rugged instrumentation for these missions will come as a result of an unrelenting development effort drawing on the latest knowhow in materials properties, electronics, and miniaturization.

Meanwhile, work will continue to go forward on the rough-landing capsule being developed for JPL by Aeronutronic in association with Hercules Powder (retrorocket) and Ryan Electronics (altimeter instrumentation).

The softer landings of Ranger's successors, Surveyor and Prospector, pose even more ticklish problems, although there is still a good deal to do first with Ranger itself, particularly in the area of sterilization to keep from spreading earth microbes on the moon.

Although the absence of a lunar atmosphere pretty well precludes the possibility of life as we know it existing on the moon, a scientific catastrophe could result if the lunar surface were to be contaminated in a lunar landing, since the only hope for learning whether living spores exist there would be extinguished if cells from earth were carried to the moon aboard a lunar vehicle.

Lockheed and JPL have been very concerned with this problem and, after preliminary design of a payload involving an Agena nose cone, have reportedly made changes because of the need for aseptic venting and biological sterility. These changes involve special sealing diaphragms and valves, and novel filters for the breathing apparatus. Component fabricators are also required to consider the effects of sterilization on circuits, mechanisms and lubricants, as well as life-detection sensors and solid-state communication equipment. Adding the trial of sterilization to those of miniaturization, shock resistance and reliability are complicating the life of the designer still further.

Meanwhile, microbiologists and immunologists continue to wrestle with the problem of sterilization itself, thus adding another job category to the growing list of recruits for the space team. All of this leads also to new problems in the areas of support equipment, handling, checkout, and launch procedures, which may shortly result in life-science experts being added to companies working in these fields as well.

For specific career opportunities, see Second Cover, pages 2, 8-9, 17, 45, 47, 65, 69, 71, and 75. ♦♦

Clean for Space

White Rooms for assembling ball-bearing devices show the attention to detail in craftmanship that is becoming more and more important to missile and space programs. This White Room was opened officially recently at GM's New Departure Div. in Sandusky, Ohio, in ceremonies commemorating the pioneering group's 25th year of precision ball-bearing production.

(CONTINUED FROM PAGE 26)

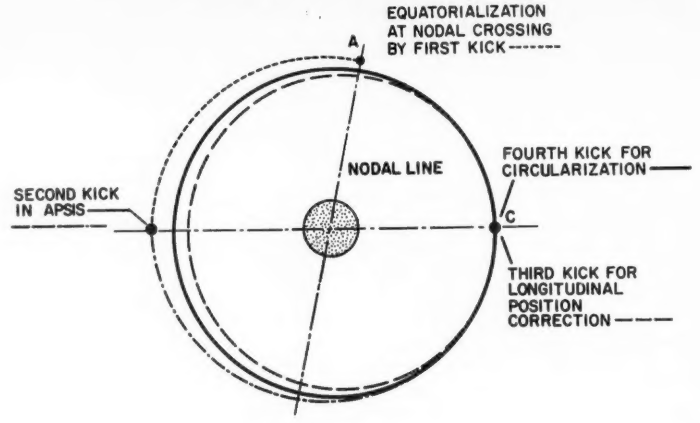
with the first impulse for guidance-error compensation. These deviations in position and velocity, as a result of injection inaccuracies, must be computed from ground-tracking data on the satellite; and it is proposed that they be given to the satellite-positioning system through a digital-command link.

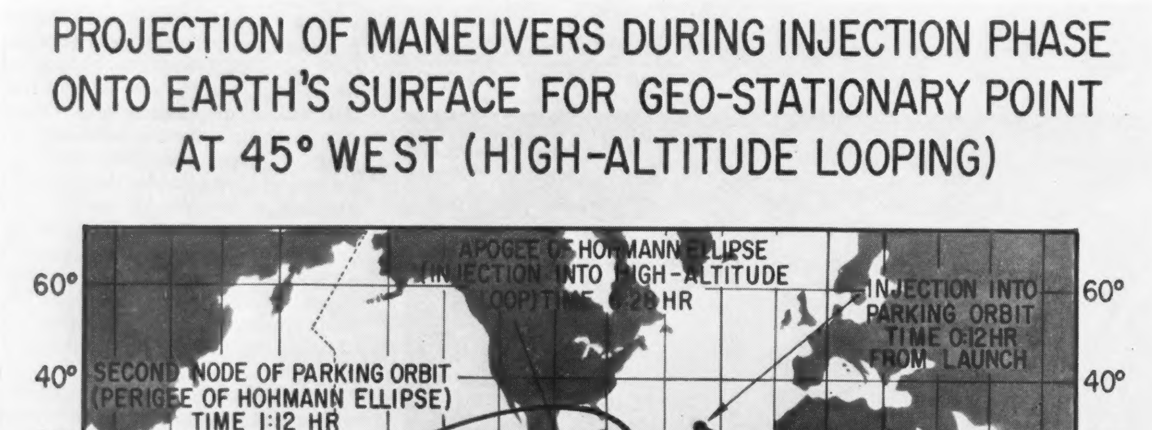
To obtain a simple guidance and control system, a scheme for orbital corrections should be applied which requires only longitudinal and lateral impulse directions. The scheme here does not feature minimum-energy requirements, but it is believed to be an engineering compromise in view of hardware simplicity and reliability.

An example of a positioning maneuver is shown in the chart on page 70. At the first nodal crossing of the erroneous orbit and the equatorial plane, an impulse in lateral direction must be applied to compensate the satellite-velocity component normal to the equatorial plane. Thus, this first kick "equatorializes" the following flight path, which, in a general case, is elliptical. The second kick will be applied at the first or second apsis of the ellipse, and has to be of such a magnitude in longitudinal direction that, after a coasting phase of 180 deg in the new orbit, the satellite will arrive at the correct geostationary radius. Here the longitude correction will be initiated with the third kick in tangential direction. Its impulse has to be selected to such a magnitude that the desired longitudinal position will be obtained after a number of complete revolutions, similar to the formerly described high-altitude looping procedure. When this position is reached, the fourth impulse will circularize the orbit.

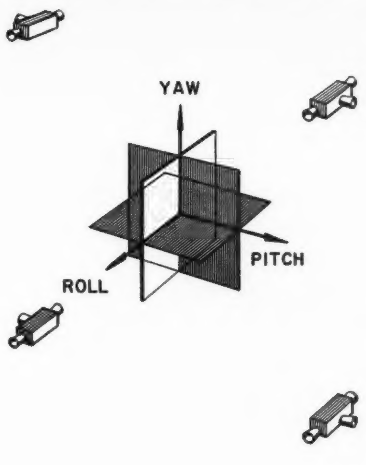
The configuration of the communication satellite itself, shown in the illustration on page 24, is based on components which can be developed with present-day means or minor additional effort. Sun-oriented solar cells provide the power for the satellite. They are mounted on a solar deck that has an angular freedom of 180

Schematic of Orbital Vernier Phase





Reaction-Controls Scheme



deg around the north-south axis of the satellite body, which itself rotates with sidereal speed. Whenever the satellite is in opposition or conjunction with respect to the earth and the sun, it is controlled to rotate about its yaw axis by plus or minus 180 deg, as shown in the top drawing on page 68. This proposed scheme provides that the solar-cell battery can be connected with flexible cables (without the use of sliprings) to the satellite instrumentation, and that perturbing angular impulses about the roll and yaw axes, as produced by solar radiation pressure, cancel out almost completely.

The signals for the orientation toward the earth can easily be given by horizon scanners sensitive to infrared light; they will furnish the roll and pitch information with an accuracy of 0.1 deg. To obtain a signal for angular displacement about the yaw axis is more difficult. It can be derived from a sun seeker except during periods in which the yaw axis forms small angles with the line to the sun and during the time the satellite travels through the shadow of the earth. Thus, either an attitude reference storage, as a gyro can offer, has to bridge these periods without information, or another method has to be applied. A very promising one can be seen in an ultra-high-frequency link which gives an attitude signal derived from amplitude comparison of radiation in two mutually perpendicular polarization planes emitted on a time-shared basis.[4] This method also permits proper control from the ground to rotate the satellite plus or minus 180 deg when it passes the earth–sun line.

The high weight allowance for a communication satellite, if launched with the Saturn vehicle, permits the use of redundant critical equipment, which can be exchanged against failing components in a kind of self-healing process. This requires that, in case of losing attitude control, either due to a failure of an attitude-control component or due to excessive actuation requirements, a reorientation cycle has to be initiated. In such a re-erection cycle, the infrared horizon scanners and the sun seeker will provide the best reorientation sensors, since they can cover wider observation angles than most other means.

The sun sensor should point toward the sun at all times. Therefore, it will best be mounted to the solar deck, which is normal to the equatorial plane. To keep the system simple, no tilt mechanism is provided for these decks to compensate for the solar declination angle. Since this angle does not exceed 23 deg during the year, the power loss, amounting to 8% at this maximum angle, is acceptable. But the correct yaw-attitude signal can only be sensed if the sun sensor is compensated or tilted against the equatorial plane by the instantaneous declination angle, which goes through a complete cycle in one year. The insert in the illustration on page 24 indicates the introduction of the declination tilt angle for the sun-seeker telescope.

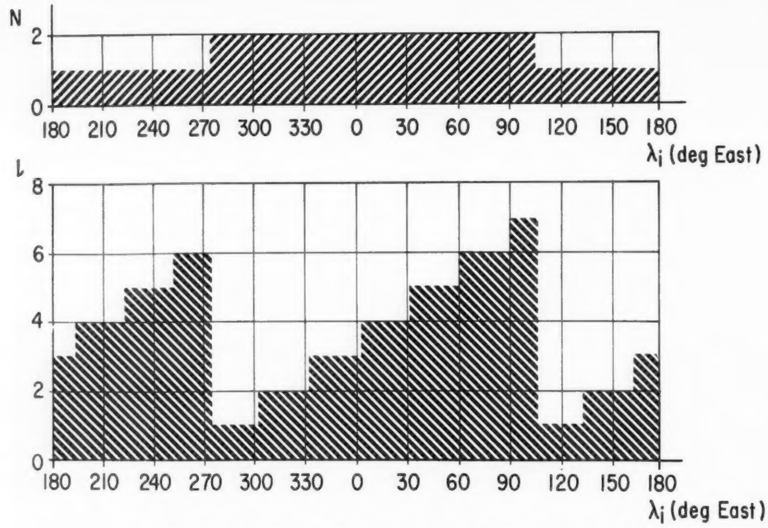
Reaction-Jet Control

Position control requires translational acceleration, which can be provided effectively only by a reaction nozzle system. The presented scheme for position control requires only longitudinal forces and forces which are normal to the flight plane; it does not need any radial forces with respect to the flight path. Thus, a scheme for twelve individual reaction nozzles, as shown schematically in the drawing on this page, can satisfy position and attitude requirements for actuation without undesirable cross-coupling effects of the three axes (pitch, yaw, and roll) and the two directions for position control. Hot gas generated by hypergolic propellants might be used in such a nozzle scheme to obtain high specific impulse. Reference is made to publications by members of the Naval Ordnance Test Station in the October 1959 *Astronautics*.[5]

It can be expected that the satellite position can be controlled very accurately and to a small drift rate. This will help hold the fuel requirements to a minimum, such as a few pounds per year, to compensate for solar radiation pressure. To reduce the fuel requirements further, it is desirable to minimize the nozzle operation for attitude control. This is possible by augmenting the nozzle scheme with a rotational acceleration system in which the

fuel requirements are replaced by power requirements. Three flywheels in a mutually orthogonal arrangement can provide the necessary reaction torques with modest power requirements.

However, in any rotational acceleration system for actuation, the total angular impulse is limited by the maximum permissible speed of the flywheel or the angular momentum of the gyroscope required. If one-sided perturbation torques occur, such as those due to solar radiation pressure on a dissymmetrical satellite configuration, the rotational acceleration system has to be discharged whenever it becomes saturated. This function, as well as producing torques higher than available from the rotational acceleration system, is then exerted by the nozzle attitude-control system.



MINIMUM NUMBER OF LOOPS (L) AND PARKING ORBIT DEPARTURE NODE (N) REQUIRED FOR HIGH-ALTITUDE LOOPING AS A FUNCTION OF DESIRED INJECTION LONGITUDE (λ_i) FOR RESTRICTED SECOND APOGEE VELOCITY INCREMENT ($\leq$100 m/s)

Spherical Flywheel Promising

Since the body of the communication satellite rotates with the angular speed of the earth to keep the body-fixed antennas earth-oriented, the spin axes of two of the three body-mounted, single-axes flywheels (controlling yaw and roll) will have to rotate with sidereal speed about the pitch axis. In addition, the pitch and roll axis will be turned 180 deg about the yaw axis whenever the satellite passes the earth-sun line. Thus, an angular momentum transfer between the flywheels has to take place in such a way that the vectorial sum of the angular momentum remains constant with respect to direction and magnitude. This, in turn, means a coupling effect of all three axes and additional average power requirement.[6] In contrast, a spherical flywheel can keep its spin axis space-fixed and, therefore, seems to be a very promising actuation system. It will have to be supported by a low-power-consuming bearing, such as a magnetic bearing[7] or an electrostatic bearing,[8] and be driven by torquing stators in a mutually orthogonal arrangement.

To conclude, we might say that it is to a greater extent an engineering effort than a research task to develop the hardware for positioning a communication satellite precisely over a selected subpoint on earth and, further, to have it attitude-controlled for antenna orientation. Progress on the state of the art is still desirable in some areas, such as lifetime of materials and components under high vacuum and power supplies of higher efficiency than that obtainable with solar cells.

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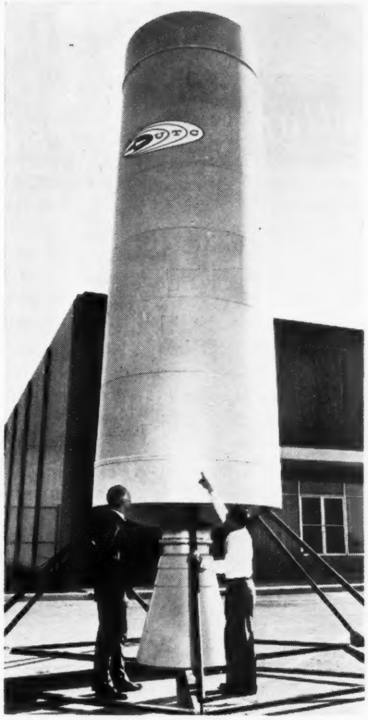
IES Elects New Slate Of Officers for 1961

The Institute of Environmental Sciences has elected Arthur B. Billet, Vickers, Inc., president, at its annual meeting. Other appointed officers include Donald J. Fox, Fenwal, Inc., executive vice-president; Mark Christensen, Wyle Laboratories, fiscal vice-president; Gerhard Deering, Columbia Research Labs, local Chapter vice-president; Herbert J. Saunders, Vap-Air Div. of Vapor Heating Corp., membership vice-president and John D. Campbell, Philco Corp., publications vice-president. Henry Sander was appointed executive secretary.

A Really Big One



This is a full-scale model of the 250,000-lb-thrust conical segmented solid-propellant rocket motor that United Technology Corp. will static-fire this summer in the development program it is conducting under contract to NASA. The model was unveiled during ceremonies dedicating UTC's new Research and Engineering Center, which includes its testing facilities, on the San Francisco Peninsula.

Chronicle of Missile and Astronautics Events Issued

The House Committee on Science and Astronautics has issued a compilation of missile and astronautics events dating from 1686 when "Sir Isaac Newton described how an earth satellite is placed in orbit" through Feb. 22, 1961. Also in this report, entitled "A Chronology of Missile and Astronautics Events," are summaries of U.S. and USSR satellites and planetoids, listings of other launchings, congressional reports, and bills pertaining to the astronautics field, public laws, and NASA appropriations. The 189-page publication, House Report No. 67, is available from the Supt. of Documents, U.S. Govt. Printing Office, Washington 25, D.C., for 55¢.

ASTRONAUTICS Data Sheet — *Propellants*

Compiled by Stanley Sarner, *Thiokol Chemical Corp., Elkton Div., Elkton, Md.*

ALUMINUM BOROHYDRIDE, $Al(BH_4)_3$

Aluminum borohydride is a colorless compound which decomposes slowly at room temperature with the evolution of hydrogen. The decomposition rate decreases with time due to the inhibiting action of one of the decomposition products. The fuel can be stabilized by heating for 4 days at 104 F in a closed container and then stored at 80 F or lower. A glassy residue is formed which is soluble in the fuel and will stabilize fresh fuel.

The instability above room temperature, even when treated, severely detracts from its use as a storable rocket fuel; but it is possible that $Al(BH_4)_3$ may find use as a solvent or adduct-former for combination fuels.

Hazards

Aluminum borohydride is not sensitive to mechanical shock, but the vapor detonates spontaneously and violently with air containing only traces of moisture. The vapor does not appear to react with dry air.

Chills and fever have resulted after exposure to $Al(BH_4)_3$ but no aftereffects have been observed. Skin contact results in chemical burns, so gloves, protective clothing, and face shields are recommended. The value of 0.01 ppm for maximum allowable concentration is estimated by comparison with B_5H_9 and the alkylboranes.

The fuel should be stored in sealed containers under a nitrogen blanket in a cool place. For quantities up to 200 lb, a storage building 50 ft away from other storage areas and 800 ft from inhabited buildings has been recommended.

Materials for Handling

Not too much information is available on the compatibility of materials with aluminum borohydride. Laboratory quantities may be stored in glass containers, but stopcocks should be avoided since $Al(BH_4)_3$ attacks stopcock grease. Stainless steel, mild steel, or iron are satisfactory metals. Copper and copper alloys should probably be avoided since they tend to accelerate the decomposition of similar compounds. Teflon and Kel-F are most likely suitable elastomers.

Cost and Availability

There is no production of aluminum borohydride at present and therefore laboratory samples would be priced quite high (about \$100–\$500/lb) up to several thousand pounds. If large-scale production were required, the fuel could be manufactured from $NaBH_4$ and would be somewhat cheaper.

Physical Properties of $Al(BH_4)_3$

Boiling Point	44.5 C	112.1 F
Freezing Point	—64.46 C	—84.03 F
Density at 0 C (32 F)	0.570 g/cm^3	35.6 lb/ft^3
at 25 C (77 F)	0.549 g/cm^3	34.3 lb /ft^3
Vapor pressure at 0 C (32 F)	0.157 atm	2.31 psia
at (extrapolated) 25 C (77 F)	0.474 atm	6.96 psia
Viscosity at 0 C (32 F)	0.280 centipoise	—
at 25 C (77 F)	0.210 centipoise	—

Chemical Properties of $Al(BH_4)_3$

Heat of Formation (liquid) at 25 C	—74.7 Kcal/mole
Heat of Formation (gas) at 25 C	—67.8 Kcal/mole
Heat of Vaporization at 25 C	6.871 Kcal/mole
Heat of Fusion at Freezing Point	1.680 Kcal/mole
Heat Capacity at 0 C	44.3 cal/mole-^{0}C
Maximum allowable concentration (estimated)	0.01 ppm

Theoretical Performance of $Al(BH_4)_3$*

Oxidizer	Specific Impulse (sec)** Frozen Flow	Equilibrium Flow	Chamber Temp Deg K***
F_2	—	350	4500
ClF_3	263	285	4425
H_2O_2	—	300	3000
O_2	315	—	3600

* These data are approximate and should not be used for calculations.

** $P_c = 1000$ psia; $P_e = 14.7$ psia; optimum O/F ratio.

*** Corresponds to equilibrium flow impulse when data for both assumptions are present.

CUT ALONG THIS LINE

In print

Anyone interested in rocketry will welcome the re-issue by Prentice-Hall of Robert H. Goddard's **"Rocket Development"** (222 pp., $2.45 paper-bound and $3.95 cloth-covered), containing the diaries and notes covering Dr. Goddard's liquid-rocket experiments from 1929 to 1941. Edited by Esther C. Goddard, widow of the U.S. rocket pioneer, and G. Edward Pendray, long-time associate of Dr. Goddard and ARS Founding Member, the new edition includes a long biographical sketch by Dr. Pendray and an introduction by the Editors. A major contribution to the literature, "Rocket Development" is deserving of a place in any self-respecting library of books on rocketry and astronautics.

* * *

Neither **"Russia's Rockets and Missiles"** by Albert Parry (382 pp., Doubleday, $4.95) nor **"Soviet Space Technology"** by Alfred J. Zaehringer (179 pp., Harper, $3.95) contribute significantly to our knowledge about the Soviet space program. Each is compounded out of equal parts of fact, rumor, and sheer speculation. Unfortunately, the Russians simply have not talked or written about the two most important parts of their space program—the vehicles they have used (and the propulsion systems which power them) and the guidance systems employed. Until they do, what they have accomplished is a much more reliable indication of their space capability than potboilers like these.

* * *

While Walter Sullivan's **"Assault on the Unknown"** (460 pp., McGraw-Hill, $7.95) will be of interest to astronautical engineers and scientists primarily for those chapters dealing with the U.S. and Soviet IGY satellite and rocket programs, the book itself is *the* definitive history of the IGY, and a worthwhile addition to any library. Written by the chief science writer of the *New York Times*, already winner of a George Polk memorial award for his coverage of the IGY, "Assault on the Unknown" is a beautifully written, carefully documented account of what has been described as "the single most significant peaceful activity of mankind since the Renaissance and the Copernican Revolution."

* * *

Kurt Stehling's **"Project Vanguard"** (312 pp., Doubleday, $4.50) is the story of this nation's first, and probably most frustrating, satellite program, written by the head of propulsion for the project. Anyone who has ever heard Kurt Stehling speak at an ARS meeting knows that he can be one of the funniest men in the world when he sets his mind to it. In "Project Vanguard," he has not only told the full story of Vanguard as he and the other members of the Martin-NRL team lived it, but has also managed to make it one of the most entertaining stories you're ever likely to come across. The satire on a typical radio-TV program found on pages 184–188 alone is almost worth the price of the book.

* * *

The late Heinz Gartmann was one of the founders of the IAF and for some 15 years the leading German writer on rocketry and astronautics. His last book, **"Das Bildbuch der Weltraumfahrt,"** or **"The Picture Book of Space Flight"** (144 pp., Umschau Verlag, Frankfort, W. Germany, price not listed), is probably one of the most beautiful books on astronautics ever published. While the brief text is in German, no knowledge of the language is necessary to enjoy almost 100 pages of excellent photographs and art work, reproduced in a manner no American publisher has thus far been able to approach. Every collector of astronautical literature will want this one.

* * *

Government Data Publications, 422 Washington Bldg., Washington 5, D.C., in its **"1961 Space Volume"** and **"1961 Missiles Volume,"** offers handy compilations of data in these two areas, this year indexed better and spiralbound in stiff cardboard covers. The "Space Volume" itself is divided into three separate books, devoted to space projects, satellites and R&D work, and includes both funded projects and proposals of every conceivable kind. The "Missiles Volume" is also divided into three parts, covering the missiles themselves, missile R&D, and contracting. Still offset-printed from typewritten masters utilizing various kinds of type, the volumes are no beauties but could prove useful. Prices are $25 each for the "Space Volume" and "Missiles Volume," or $40 for the set.

* * *

Chilton Co. has launched what could be an important project with Volume 1 of its new series entitled **"Men of Space"** by Shirley Thomas (235 pp., $3.95), containing "profiles" of ten "leaders in space research, development, and exploration." While the selection of the leaders seems somewhat arbitrary—why, for example, Goddard and Tsiolkovsky, but not Oberth? Schriever, but not Medaris? Yeager, but not Crossfield? And why Von Neumann at all?—and the writing pedestrian when it is not being sob-sisterish, the profiles do provide helpful details about the lives, careers, and personalities of several distinguished figures. As a first attempt, the book is not entirely successful, but if the publisher and author can decide whether they are aiming at a popular or reference series, succeeding volumes could be of great interest, especially when foreign personalities, who are not so well known, are included.

* * *

Anyone searching for a comprehen-

sive rundown on U.S. and foreign missiles and space vehicles would do well to examine "**International Missile and Spacecraft Guide**" by Frederick I. Ordway III and Ronald C. Wakeford (about 450 pp., large format, McGraw-Hill, $25). This impressive volume begins with a long background section which covers the organization of missile activities in various countries, early developments in the various types of missiles, rockets and spacecraft, and test missiles, drones and special vehicles. The following section covers these subjects on a country-by-country basis, with the activities of 11 nations included. Amply illustrated, well-written and attractive in format, this encyclopedic presentation of the facts and figures on the world's missiles and space vehicles should prove a most welcome reference work.

* * *

In "**Russian Science in the 21st Century**" (222 pp., McGraw-Hill, $4.95), 29 leading Soviet scientists peer into the future and predict a world which may well be in the making in the next 50 years. The book is almost a blueprint of future plans for Soviet science, since the editors, Sergei Gouschev and Mikhail Vassiliev, are on the staff of *Komsomolskaya Pravda*, the Soviet youth publication, and gathered the material for the magazine while the USSR was preparing for the 6th World Festival of Soviet Youth and the 40th anniversary of the October Revolution back in 1957. As such, it makes for very thoughtful reading. While those chapters dealing with space exploration and lunar colonization will be of special interest, the entire book deserves the careful attention of all American scientists and engineers, since it points up very clearly the magnitude of the challenge the U.S. technological community will face in the next half-century.

* * *

"**Ninety Seconds to Space**" by Jules Bergman (224 pp., Hanover House, $4.50) is, as the subtitle suggests, "the story of the X-15," as well as the story of the pilots who fly it, the experimental rocket aircraft which preceded it and those which are likely to succeed it. Factual, well-written, and admirably illustrated with 150 photos, many of which have not previously been released, it's an excellent job. However, it seems a bit premature, since it concludes with an *imaginary* flight to altitudes and speeds for which the vehicle was designed, rather than an actual description of such a flight. It seems a pity that publication could not have been delayed until such flights do become fact. —**I.H.**

BOOK NOTES

"Planets, Stars and Galaxies" by Stuart J. Inglis (474 pp., John Wiley). A lucid, concise, and well-organized introduction to astronomy.

"Missile and Aircraft Procurement Management" by C. O. Nelson (140 pp., Vantage, $4). A comprehensive study of procurement practices in the missile and aircraft industries by the head of subcontracting for Sperry-Utah's Engineering Lab.

"Aerospace Dictionary" by Frank Gaynor (260 pp., Philosophical Library, $6). A cut-and-paste reference work of value primarily to those who do not already own the much more complete Besserer and Besserer or Grayson Merrill dictionaries.

"Reaching for the Stars" by Erik Bergaust (407 pp., Doubleday, $4.95). A bland biography of Wernher von Braun.

"The 1961 Aerospace Year Book" (483 pp., large format, American Aviation Publications, $10). Official publication of the Aerospace Industries Assn., crammed with facts and figures about military and civilian aviation, the industry, missiles, etc. ♦♦

IBM Moon Bit

An example of advanced projects underway at IBM's new Research Center in Yorktown, N.Y., this cell contains a semiconductor element (silicon) immersed in a liquid electrolyte (sulfuric acid). It detects light from a weak source such as the moon with high angular resolution, yet withstands exposure to intense direct sunlight. IBM scientists are developing the cell for NASA as a satellite-orientation sensor. It is rugged, says the company, and can operate for 7 yr on a 1.36-v battery the size of a penny.

Panama Hypothesis

(CONTINUED FROM PAGE 39)

We believe that the general historical pattern of exploration, development, and colonization of such areas as the Western Hemisphere, Africa, and Australia will be repeated in space. Although the moon and other extraterrestrial real estate may initially seem even less desirable than the Antarctic, we will find that special advantages not present anywhere on earth will more than offset the disadvantages.

The moon, because of its low gravity and lack of atmosphere, is a "Panama Canal" to the riches of the deep space "Pacific" beyond. Space vehicles bound for Mars, Venus, and elsewhere in the solar system could carry far greater payloads, or have greatly reduced flight-time, if refueled by moon-based tankers with propellants produced on the moon.

Certain regions of the moon will offer uniquely desirable combinations of natural resources, favorable terrain, strategic position, etc. analogous to Gibraltar, Suez, Mesabi, Pittsburgh, the Middle East oil fields, etc.

The Panama Theory cannot be proved at this time. Even if only 20% probable it represents a strong argument for urgency in our man-in-space program. When the Panama Theory has been proved, as we believe it will be in the near future, it will be too late to overcome the decisive lead of the opposition.

The Panama Theory rests on at least five conditions, and possibly some others which have not been identified. Although none of the five can be proved at this time, all are highly probable and all rest squarely on strong historical precedents. The five conditions are as follows:

1. *Life in Space.* The ability of man to live and work beyond the earth's atmosphere.

2. *Low Transportation Cost.* The ability of our technology to reduce space transportation costs to reasonably low levels eventually.

3. *The Need.* The scientific, military, economic, and socio-political reasons for extraterrestrial colonies.

4. *Preferred or Strategic Areas.* The critical importance of the moon itself, and the almost certain existence of a relatively few key areas on the moon.

5. *International Competition.* Even under a condition of general world disarmament, economic competition would continue, particularly between communist countries and the free world. Russia might claim Lunar Panamas or Mesabis, if in a position to do so, and thus acquire a significant advantage in the future exploration and development of the solar system. Of these five conditions, only the questions of transportation cost, need, and preferred areas will be examined in more detail.

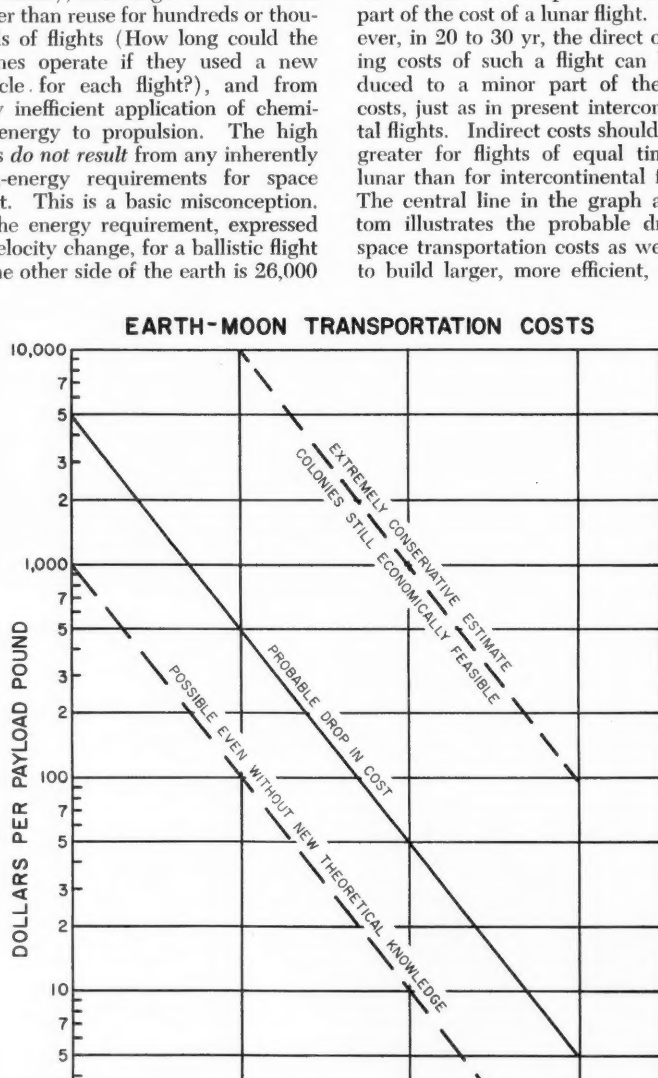
Cost Reduction

Extraterrestrial bases and colonies could not be supported with space-transportation costs at the present high level. Present high costs result primarily from the very high research and development costs needed for a rapid breakthrough into a new technological era, from vehicles of inefficient size (too small), from single use of vehicles rather than reuse for hundreds or thousands of flights (How long could the airlines operate if they used a new vehicle for each flight?), and from early inefficient application of chemical energy to propulsion. The high costs *do not result* from any inherently high-energy requirements for space flight. This is a basic misconception.

The energy requirement, expressed as velocity change, for a ballistic flight to the other side of the earth is 26,000 fps. A return flight would have the same requirements. Thus, the total would be 52,000 fps. A trip to the surface of the moon and back requires a total velocity change of only 53,000 fps.

Ballistic flight to the antipodes is one of the cheaper ways to travel. It requires less energy than "boring a hole" through the atmosphere with an aircraft for the whole distance or even less than driving a truck an equivalent distance.

Actually, the vehicle and propellant costs represent only a minor fraction of the total cost of a passenger flight to Australia, while in the near future these items would represent the major part of the cost of a lunar flight. However, in 20 to 30 yr, the direct operating costs of such a flight can be reduced to a minor part of the total costs, just as in present intercontinental flights. Indirect costs should be no greater for flights of equal time for lunar than for intercontinental flights. The central line in the graph at bottom illustrates the probable drop in space transportation costs as we learn to build larger, more efficient, recov-



erable space vehicles, and employ propulsion systems of higher performance. Based on vehicles already contemplated, these costs could drop as rapidly as indicated by the lower line. Even if we take very pessimistic figures and arbitrarily multiply our design estimates by a factor of 20, we still have cost figures (upper line) that would permit economic operation of space colonies by 1980.

The Need

Only one long-range vital need must be established for large-scale manned space flight to make the loss of space "Panamas" to an unfriendly power a catastrophe. This need might be one which can be identified now and which follows historic precedent. It could, however, become apparent only after our exploration of the moon and the planets. Needs can now be identified in all of the four categories—scientific, military, economic, socio-political.

Major scientific breakthroughs most often occur when we enter a whole new area of nature—such as the germ theory of disease following the discovery of the microscope and the access it gave to the world of the microbe. The atomic-energy breakthrough followed the invention of the atom smashers and the entry into the world of the atomic nucleus.

Initial remote study of the solar system led to the enunciation of the most fundamental laws of science. But our observation of the universe around us has been obscured by our atmosphere and the immense distances to other worlds in space. Our limited conclusions about conditions on other planets are based on very sketchy and relatively inaccurate evidence. It would be surprising if some major revolution in scientific thought did not follow the close and accurate observation of the extraterrestrial universe made possible through manned space flight.

The balance between space, time, and destructive power has been completely disrupted by the emergence of the nuclear bomb and the ballistic rocket. A return to relative pre-atomic security and stability can be achieved only by establishing military deterrent systems in space.

Obsolescence of military systems is a necessary and inevitable consequence of the advance of technology. We know that Polaris and other current weapon systems will become obsolete in the not very distant future whether or not we can describe in detail the counterweapons that will neutralize them!

Is a half-hour of warning time sufficient for deciding whether to destroy the human race? How can this time

be increased? Only by establishing space-based deterrent systems at sufficient distance from the earth so that attacking weapons will need days or weeks to reach them.

The space-deterrent fleet will once again have the combination of dispersal, mobility, invulnerability, warning time, and flexibility which have been lost to all terrestrial systems through the development of ballistic missiles and atomic bombs.

As living space implodes around us from 340 acres per person in the time of Christ to 12 acres per person in 1960 and to an estimated 1 acre per person in 2020, our natural resources will be depleted at an ever-increasing rate. Having the low space-transportation costs which can be expected in a generation, resources can be carried in from space after processing or even as raw materials.

Will the heritage which we leave for our grandchildren be a single remaining island of freedom and western culture in a communist solar system?

If a nuclear rocket capable of leaving the earth's gravity field is refueled at escape velocity, it could cut its trip time to Mars from perhaps 6 months (depending on the position of the planet) down to about 2 months. It would be worth a considerable expense to be able to refuel with liquid hydrogen when crossing the moon's orbit, for example.

Companies on the Moon?

A company which manufactured liquid hydrogen on the moon would be in a highly favored position for resupplying such a nuclear rocket. It would be necessary to provide a moon-based tanker with a velocity of only 8000 fps to achieve rendezvous with the earth rocket, whereas an earth-based tanker would need 37,000 fps. It would take an additional velocity change of only 8000 fps to recover the empty moon tanker, compared to 10,000 fps for the earth tanker. Thus, the lunar propellant manufacturer could sell his liquid hydrogen at a much lower cost.

A military space vehicle on patrol in deep space could refuel on the moon far more easily than returning to earth. Besides the problem of gravity, reentry and subsequent takeoff from the earth requires an entirely different type of vehicle than the deep-space patrol ship. A single-stage nuclear patrol ship could make periodic trips to a moon base for refueling, resupply, recreation, etc. No tankers would be required for this operation.

What is the possibility or probability that hydrogen—needed for nuclear rocket propellant, for water, for food, etc.—will be available on the moon? A few years ago, this question would have been lightly dismissed by some scientists with the categorical statement that there is no water or hydrogen on the moon. Now a second more careful look is being taken, and the general belief is that there will be considerable water in the form of water of crystallization in the lunar rocks. One estimate indicates that 1% of the lunar surface may be water. While this is far less than the percentage of water on earth, it nevertheless represents a very considerable tonnage. Harrison Brown, Harold Urey, V. A. Firsoff, I. M. Levitt, Zdenek Kopal, and Thomas Gold are among prominent scientists who have very recently predicted that water in quantity would be found on the moon.

Suppose the Russians set up bases on the moon and manufactured propellants, etc. Why can't we do likewise? According to our present schedule we may not land on the moon for 5 yr after the initial Russian landing. During this period they could set up several bases in strategic areas and could easily establish military control—with small missiles—of the whole moon. They would only be following historical international precedents if they laid claim to the whole moon. Any U.S. landing would then be an act of aggression and they would be justified in destroying our landing vehicle.

Suppose that we accelerate our program to the point where their moon landing occurs only 2 yr before our own? In this case they might not be able to defend a claim to the whole moon. However, they could occupy the choice locations and thus exclude us from their use.

There is a reasonable chance that ice exists on the moon, but probably only at the poles. It would be catastrophic if the only rich sources of this high grade "hydrogen ore" were discovered and claimed by Russia.

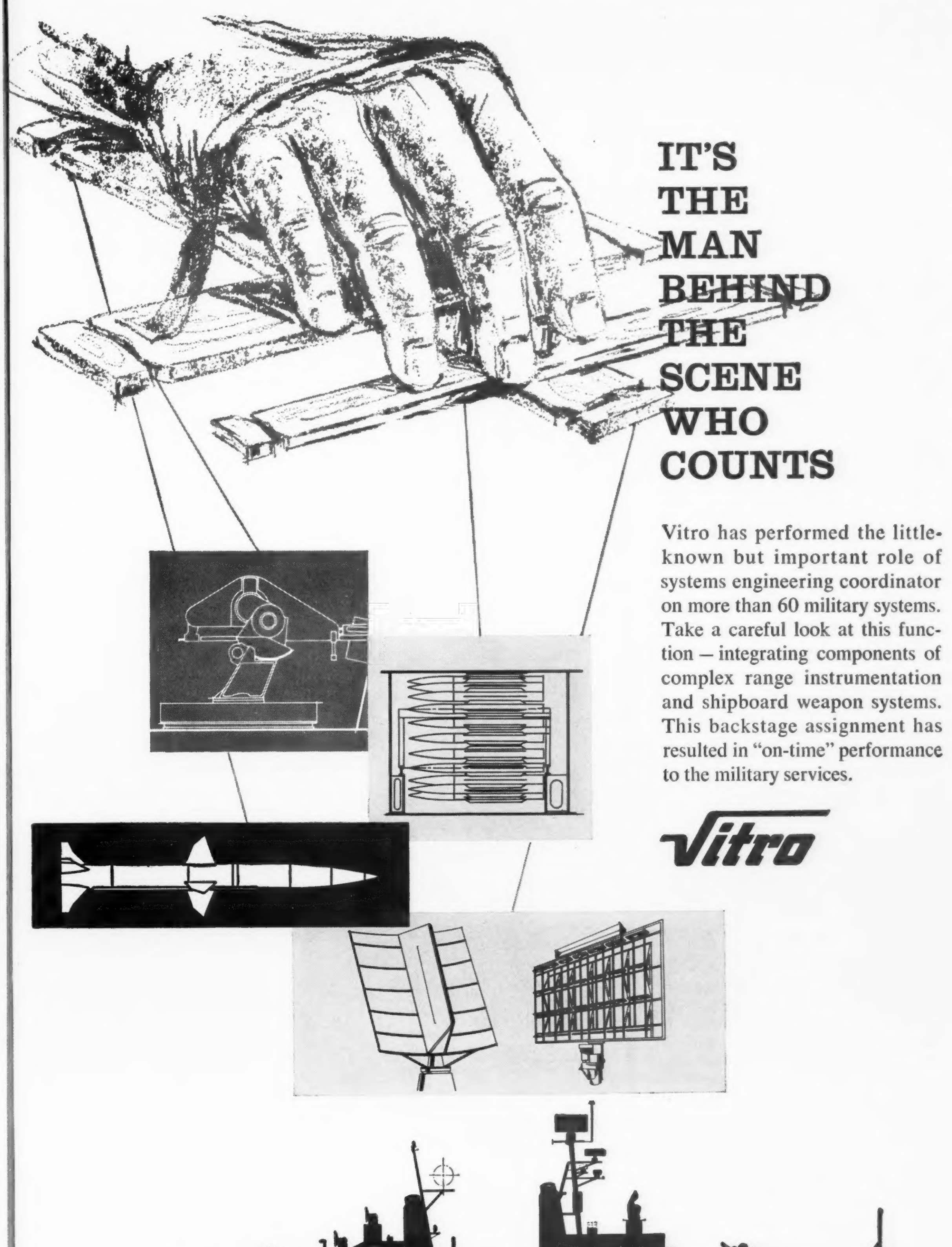
Results

What are our attitudes toward such matters? As mentioned, we have made a survey concerning the Panama Hypothesis. A sample of the questionnaire has been reproduced here for the reader's benefit. The table on page 39 shows the results from the poll, with question numbers corresponding directly to the numbers of the sample questionnaire.

Note that average results were obtained by simple arithmetic averaging

Amazing Motions

Two engineers and a capsule containing liquid hydrogen undergo weightlessness during a modified Keplerian arc flown by a KC-135 jet aircraft over Ohio. Such flights are part of a study of the behavior of liquid propellants for space vehicles being performed by Convair-Astronautics for NASA. Tests cover liquid behavior, heat transfer, venting, pumping, and settling under weightlessness. Closed-circuit television (Kin Tel) covers tests, which are made inside a nitrogen-filled nylon bag.


IT'S THE MAN BEHIND THE SCENE WHO COUNTS
Vitro has performed the little-known but important role of systems engineering coordinator on more than 60 military systems. Take a careful look at this function – integrating components of complex range instrumentation and shipboard weapon systems. This backstage assignment has resulted in "on-time" performance to the military services.
Vitro
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of the probabilities, assuming that the five categories could be translated into numerical values—5, 25, 50, 75, and 95%, respectively.

The most important conclusion to be drawn from the questionnaire results is that there is a strong body of informed opinion in the ARS and in NASA that believes in the probable truth of the Panama Hypothesis and considers it a good reason for acceleration of our space program.

Ninety-two per cent of those ARS officers and members responding to the poll believed it a reason for acceleration. The average ARS answer to Question 2, referring to the correctness of the theory, was 75%, or "probably true."

While NASA reaction was not as strongly positive as the ARS, it is nevertheless clear that a large group of NASA officials and scientists does support this theory and considers it a good reason for an accelerated program.

A second important conclusion that can be drawn from the results is that the theory is highly controversial. Particularly within NASA, there is apparently an important body of opinion in disagreement with the theory. It can be hoped that public discussion, clarification of reasons for differences of opinion, removal of semantic blocks, etc. will quickly resolve this controversy.

It may be further concluded from the high grouping and high average probability on Question 3a that there is general confidence on this phase of the space program. It might be noted in connection with Question 3b that more convincing analysis and more general distribution of information is required on the many designs of vehicles for future low-cost space travel (Rita, Orion, Aerospaceplane, etc.).

There may be some concern over the question of percentage distribution of opinion in the non-responding group. The Harvard Business Review concluded that division of opinion in the non-responding group was approximately the same as in the responding group, after a follow-up telephone survey in connection with a similar space-flight poll of business executives.

It may be useful to use polls of this type as a basis for public education on "what the experts think about man in space" rather than the current common practice of quoting some "authority." If we must select individuals and place great emphasis on their opinions, perhaps we should note that there is only one real authority on the subject of man in space—a young man named Yuri Gagarin. In his opinion we *are* in a race for the moon, and cosmonauts are here to stay! ♦♦

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